

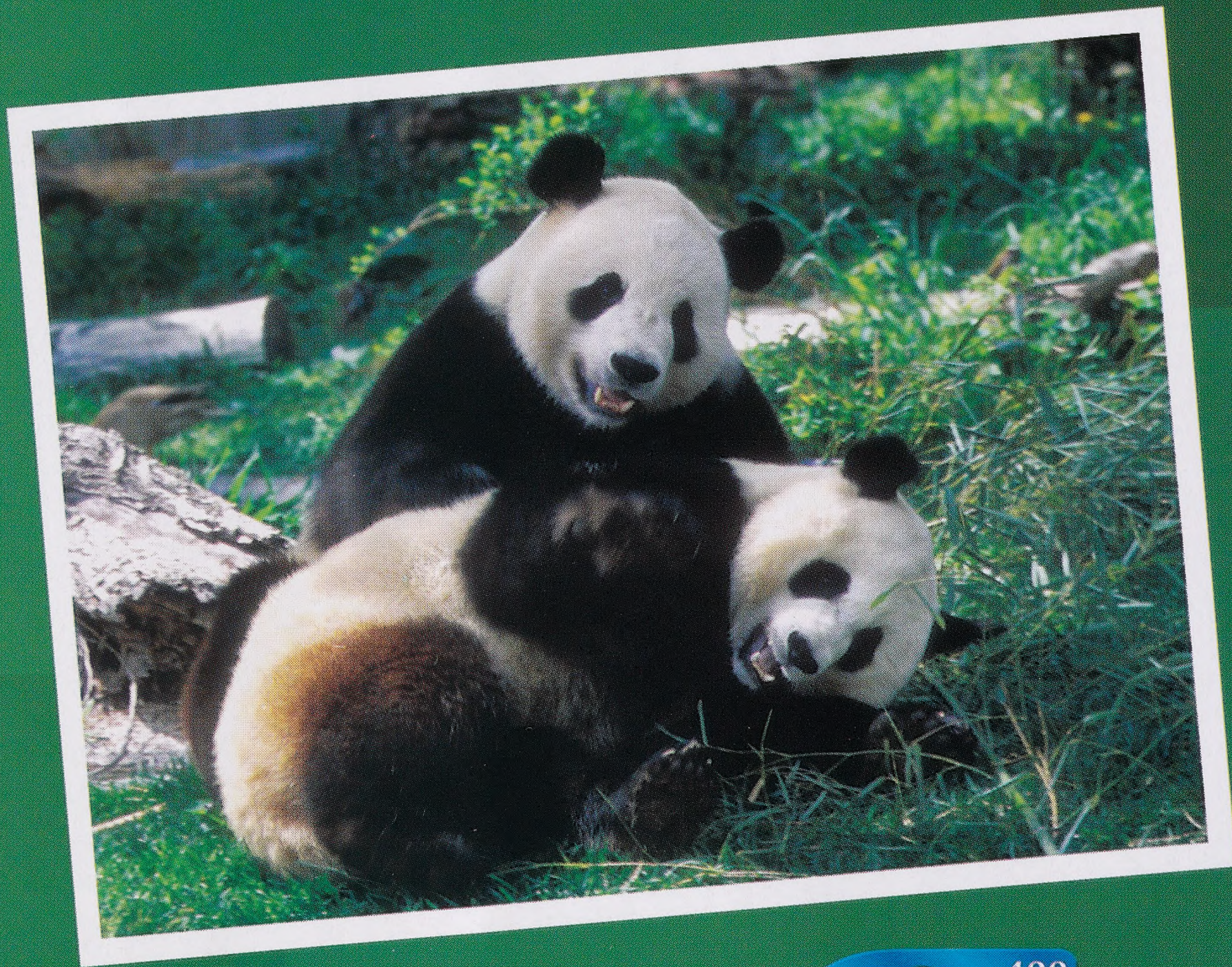
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Partners in Conservation Education

Among the best recognized, but rarest animals in the world, giant pandas have come to symbolize endangered species and international conservation efforts. In an effort to help protect the giant pandas and secure their future, Fujifilm is proud to be the lead corporate sponsor of the Zoo's giant panda program.

Fujifilm's support helped the National Zoo bring giant pandas Mei Xiang and Tian Tian to Washington, and is assisting the Zoo's experts to develop the scientific knowledge they need to ensure the survival of pandas in the wild. Fujifilm also supports comprehensive conservation education programs designed to help children and adults learn more about giant pandas and the conservation of all wildlife and their habitats.

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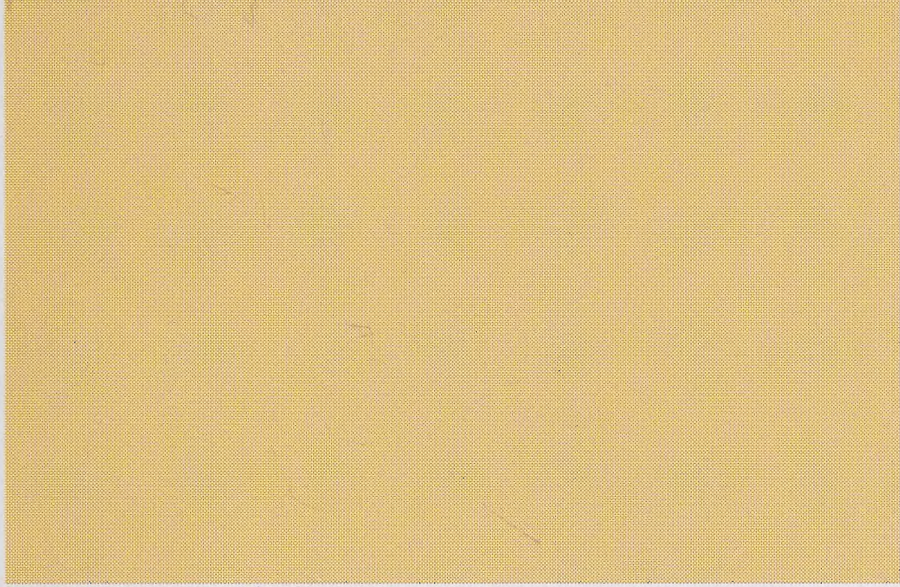


Smithsonian
National Zoological Park

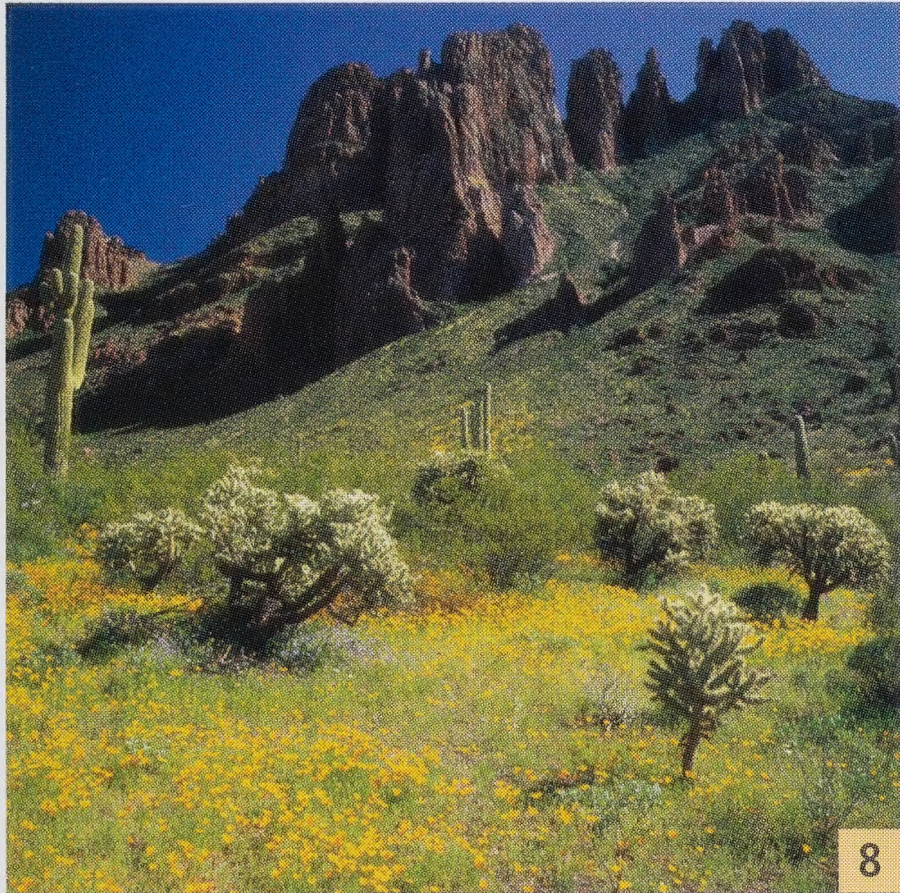


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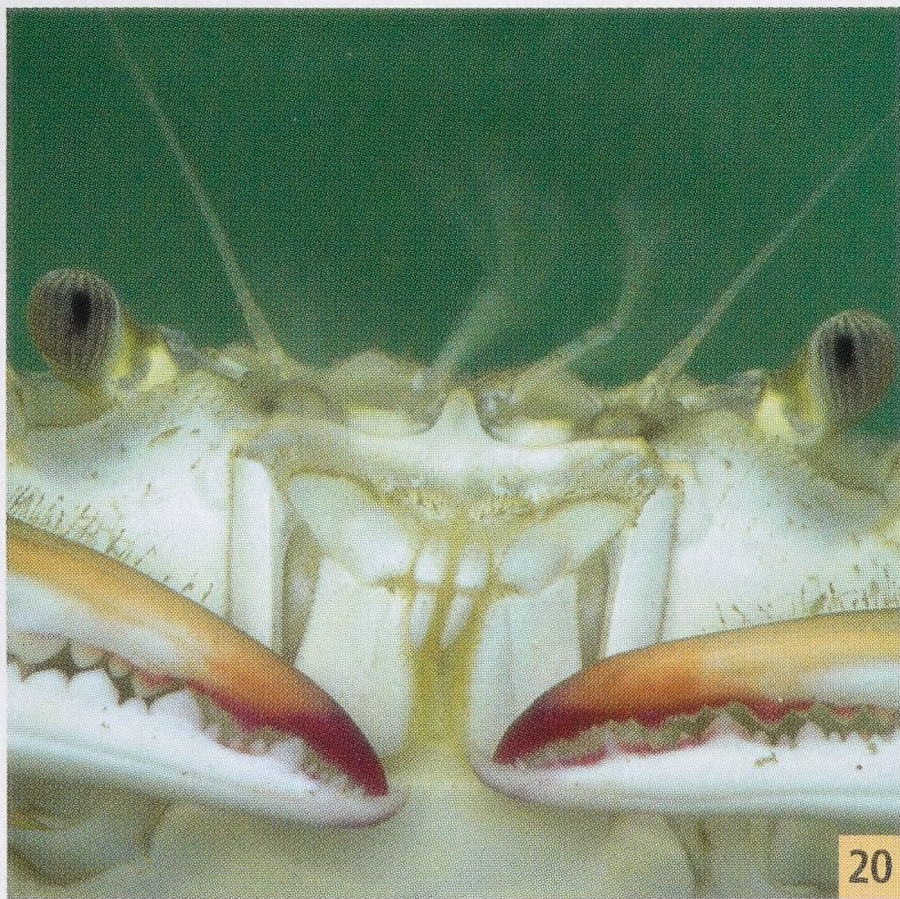
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Jessie Cohen/NZP



Bruce Coleman Inc./Jeff Foott



Susan M. Glascock



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BY ALEX HAWES

The Sonoran Desert is North America's most biologically diverse desert, but it may not remain so. As sprawl reaches its valleys, dams block its rivers, and concrete covers its fragile landscapes, its native wildlife struggles to survive. Can a new land-use strategy forge a compromise between consumption and conservation?

20 Hatching a Plan for Blue Crabs

BY STEPHEN BERBERICH

Beautiful swimmers, fearsome predators, tasty morsels—no matter what you call the most celebrated crustaceans of the Chesapeake, they're in trouble. To help blue crabs recover from a population plunge, Smithsonian and University of Maryland scientists launched the largest tag-release-and-recovery crab study in the world.

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FONZForum

In 2004, the National Zoo/FONZ website (www.fonz.org or www.nationalzoo.si.edu) logged more than nine million visits. This is an astonishing number, capped only by noting that, in these visits, people viewed more than 30 million pages altogether. The numbers, which promise to grow even greater in the future, are a testament to the extraordinary resources available on our website. The site now boasts more than 7,800 images and 7,500 pages of content, with nearly a million links among them. And our animal cams, the most popular feature of the site, now number 16, giving people unparalleled access to many of the Zoo's animals without their having to leave home or office.

The website was launched in January 2003, after a team of FONZ and Zoo staff worked for a year on its planning and development, and it remains a team effort, with staff from throughout FONZ and the Zoo helping to add new information and keep current the existing information on all of those thousands of pages. This effort has been rewarded by the great reviews the site gets from visitors from around the world. (In fact, about 20 percent of visitors come from abroad, an extraordinary amount of global outreach.) And we are most proud of the awards we received for the website's innovative Conservation Central education program.

Funded by Fujifilm, our "Partner in Education," Conservation Central is designed to teach middle-school students about temperate-forest habitat—home of the giant panda—and the challenges faced in securing the future of endangered species. Conservation Central won the "Best of the Web Award" as the Best Overall Museum Web Site from Museums and the Web; a Silver MUSE Award by the American Association of Museums; and first place in the Interactive Multimedia category for the National Association for Interpretation's Interpretive Media Competition. This is a remarkable achievement for the team of FONZ and Zoo staff who developed Conservation Central.

Of course, the site hosts a wealth of other educational material, from animal fact sheets and articles on National Zoo science to pages of "homework help," games and quizzes, and activities that families can download to enhance their trips to the Zoo. Teachers can find curricula and other resources to use in their classrooms and activity guides their students can take on field trips to the Zoo. But I see all of this as just the beginning. The web offers virtually unlimited ability to reach teachers, students, and the public. One of my major goals is to make sure we take full advantage of the web to help to create environmental literacy across the nation and around the globe.

Our website also provides many services to make your FONZ membership more convenient. You can renew your membership, change your address, request a replacement membership card, review travel itineraries, and check out the list of zoos across the country that offer free admission or other benefits to FONZ members. You can purchase gift memberships and Adopt a Species packages, and enjoy your 20 percent discount while shopping at our Zoo Store Online. You can also register for FONZ classes, camps, and special events. I know many of you already take advantage of some of these online services—for instance, nearly all of the tickets to October's Boo at the Zoo were ordered online, and 82 percent of all the tickets were purchased by FONZ members—and I urge all of you to use all of them.

I'd also like to know what else you would like to see on our website, and hear your thoughts about how your online experience could be improved. Our goal is to make your FONZ membership valuable and rewarding, and we strive to respond to the needs of our members. So your feedback, about our website and any aspect of your membership experience, is very important to us. Please send your suggestions to me at tomlarock@fonz.org. Thank you.

Sincerely,

Tom LaRock
Executive Director



is a nonprofit organization dedicated to supporting the conservation, education, and research efforts of the Smithsonian's National Zoo. Formed in 1958, FONZ was one of the first conservation organizations in the nation's capital. Friends of the National Zoo is dedicated to supporting the National Zoo in a joint mission to study, celebrate, and protect the diversity of animals and their habitats.

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Smithsonian National Zoological Park is located at 3001 Connecticut Ave., N.W., Washington, D.C., 20008-2537. Weather permitting, the Zoo is open every day except December 25. Hours: From April 3 to October 31, grounds are open from 6 a.m. to 8 p.m.; buildings, 10 a.m. to 6 p.m. From November 1 to April 2, grounds are open from 6 a.m. to 6 p.m.; buildings, 10 a.m. to 4:30 p.m.

Membership in FONZ offers many benefits: programs, publications, discounts on shopping and events, free parking, and invitations to special programs and activities to make zoogoing more enjoyable and educational. To join, write FONZ Membership, National Zoological Park, 3001 Connecticut Ave., N.W., Washington, D.C., 20008-2537, call 202.673.4961, or go to www.fonz.org.

Membership categories and annual tax-deductible dues are:

Family (includes children 3-16 years)	\$50
Double	\$45
Individual	\$40
Senior Citizen Individual	\$30
Contributing	\$75
Sustaining	\$150
Patron	\$250
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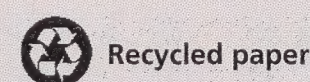
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ZooGoer is available on audio tape, for members who cannot read standard print due to disability, as part of the standard membership fee. For more information, please call 202.673.4711.

Cover photo: A barrel cactus (*Ferocactus* sp.) blooms in the Sonoran Desert. Photo by Alex Hawes.



The Smithsonian's National Zoo is accredited by the American Zoo and Aquarium Association.

Letter from the Zoo's Deputy Director



Until recently, my thoughts about the Smithsonian's National Zoo were colored by two experiences. When I was five, my big sister took me to the Zoo. I particularly wanted to see Smoky Bear. I vividly remember reaching his enclosure, in what I now know as Beaver Valley, where I saw not a famous black bear, but a sign saying that Smoky was "out fighting a fire." That I recall this episode so clearly 48 years later is a testament to how disappointed I was!

Adding to this first-hand memory are the images of the Zoo that my mother painted throughout my childhood. She grew up in a home on Park Road, just outside the Zoo, and loved to lie in bed at night listening to lions roar. She also loved monkeys. An image of a monkey in a book or film always evoked her fond memories of "her own backyard zoo." She passed away just a few years before I became the Zoo's Deputy Director. But I like to imagine her smiling and sharing my delight at the wonderful animals I see—and hear—every time I walk through our beautiful Zoo. This keeps her close to me in spirit.

These experiences remind me every day of the important place the National Zoo occupies in so many people's hearts and minds—and of our responsibility to ensure that visitors always take away positive memories of their trips to the Zoo.

Helping to run the National Zoo was not a role I ever imagined. My background is in museum and science administration; most of my 32 years at the Smithsonian were spent at the National Air and Space Museum and the National Museum of Natural History. I also worked for ten years in central administration, first in facilities and then in "the Castle," where I spent seven years before moving to the Zoo in late 2002. When Zoo Director Lucy Spelman asked me to apply for the position as her deputy, I was surprised. I had been the Under Secretary for Science's executive officer since 1996, and the Zoo was one of "my" units. But it had always been rather aloof, not only because of its distance from the Mall, but also because little information flowed from the Zoo.

In fact, my first official Zoo tour came only when Lucy, after becoming director in 2000, showed me what had happened to the Zoo as funding for staff, operations, and maintenance had steadily declined. I was shocked and sad. I saw that it was time to tie the Zoo more closely to the "mother ship." This led to my accepting Lucy's offer. I hoped my knowledge of how the Smithsonian works, the relationships I had built with our other museums and research institutions, and my years of

administrative experience would help Lucy turn things around. Little did I realize that I would face the most challenging two years of my life.

I won't revisit all of the events of the past two years that played out in the public eye. Instead, I want to tell you what has made every struggle and heartbreak worthwhile for me. Smithsonian staff are highly dedicated, and many make working here a life-long career. But the National Zoo's staff sets a new standard for dedication.

I didn't really understand what a 24/7 operation meant until I worked at the Zoo. In my position in the Castle, the prospect of a morning snowstorm had me looking forward to a day at home playing with my children. Now, while staff camp out at the Zoo so they can care for their animals in the morning, I keep my Zoo radio on and stay glued to the TV weather news. I make sure my husband's Jeep is gassed up so I can get to work, where I find that, even before dawn, some staff have cleared roads and walkways so other staff can get food to the animals and deliver any necessary vet care. I witnessed similar dedication during Hurricane Isabel, after last spring's fire in the Wetlands, and see it every day in countless non-emergency situations. This is why criticisms of the Zoo in the past few years hurt so much. A staff 15 percent smaller than it was a decade ago is working extraordinarily hard to meet higher standards than ever.

Under Lucy's strong, creative leadership, and with a hard-won infusion of support in the last two years, we began long overdue repairs, enhanced facilities staff, increased staff training, and strengthened management. Staff throughout the organization worked together for a year to develop the Zoo's first Strategic Plan, which you read about in the last issue. These and other initiatives have put the Zoo on the road to renewal.

As you read this, a new Zoo Director has likely been named. That individual will be met by a strong, caring staff anxious to continue to help rebuild the National Zoo. I will be proud to introduce them.

Sincerely,

Mary R. Tanner
Deputy Director
Smithsonian's National Zoological Park

Notes&News



Veiled chameleons are on exhibit at the Reptile Discovery Center.

Animal News

Six **veiled chameleons** (*Chamaeleo calyptratus*) hatched at the Reptile Discovery Center this fall, the first of their species ever to hatch at the National Zoo. While the chameleons are juveniles, their bodies are green and the bumps on their heads—called casques—are fairly small. Vivid bands of color will emerge on their skins as they mature. Adult males can grow up to 24 inches long and have casques as tall as two inches. They also have a feisty temperament—in battles with other males for territory or mates, they will sometimes fight to the death. In the wild, veiled chameleons live in Yemen and Saudi Arabia, usually near acacia plants and water sources.

In mid-October, the Great Ape House swung into action to welcome two new **Bornean orangutans** (*Pongo pygmaeus*). Kyle, a seven-year-old male, came from the Cleveland Zoo and is on loan from the Hogle Zoo. Batang, a seven-year-old female, came from Topeka Zoo and is on loan from Brookfield Zoo. They have been designated as a breeding pair, and came to the Zoo as part of the American Zoo and Aquarium Association's Species Survival Plan for orangutans. Hopes are high that Batang will become pregnant in the next two or three years.

Volunteer Corner



FONZ volunteer Ken Lawwill visits with a golden lion tamarin at the Small Mammal House.

Ken Lawwill is a volunteer interpreter at the Small Mammal House and Amazonia. He was pleasantly surprised to find that National Zoo volunteers often learn from visitors, too.

"When I first considered becoming an interpretive volunteer at the Zoo, I thought I knew a fair amount about animals. But as I walked through the Small Mammal House, I was struck by how many animals I didn't know. Tamarins, tenrecs, and tokay geckos? Sakis, Geoffroy's marmosets, and naked mole-rats? Of more than 25 species on display at the Small Mammal House, I knew only four. Since then I've learned a great deal about small mammals, but the more I learned, the more I realized how little I knew.

But what a place to learn! Thanks to an awesome volunteer training program, the information we acquire with every shift, and updates from keepers and FONZ education specialists, my knowledge continues to grow.

But my favorite way to learn is by interacting with the visitors. One morning last year, a boy who looked about ten years old approached the lemur enclosure with his father. When I asked the young man, "Would you like to guess what group of animals the lemurs are related to?" he replied, "They're primates!" To my amazement, he then explained the difference between simian and prosimian primates and elaborated by telling me about quite a few species. I listened for at least five minutes in amazement, and then glanced at his father. He smiled and said, "My son really likes lemurs." I sure hope they visit again while I am volunteering. I'd greatly enjoy hearing what this young man has learned since I last had the opportunity to appreciate his knowledge."

If you'd like to volunteer at the National Zoo, please visit www.fonz.org or call 202.673.4956.

Events

The National Zoo's free evening lecture series continues in 2005. To find out more, sign up for email notifications about the lectures, or RSVP, please visit www.fonz.org/lectures.htm.

January 6:

Conserving Giant Pandas in China

Lecture at 7:30 p.m.

Most Washingtonians are familiar with Mei Xiang and Tian Tian, the Zoo's famous giant pandas. But few are aware of National Zoo scientists' extraordinary contributions to giant panda studies in the wild, or of the Zoo's commitment to protecting this species in China. Zoo senior scientist David Wildt will discuss the Zoo's research and training programs and share the adventures of National Zoo experts working in China to understand and save giant pandas.

January 20: Animals in Ancient Athenian Rituals

Lecture at 7:30 p.m.

In a slide-illustrated lecture, Lynn Snyder, a zooarchaeologist at the Smithsonian's National Museum of Natural History, will talk about her fascinating findings of animal remains recovered from sacrificial contexts in the ancient Agora of Athens, Greece. Through painstaking reconstruction of fragmentary cremated animal remains, her analyses have revealed patterns of sacrifice that, in some cases, differ from those known through textual and visual evidence. This lecture is presented in cooperation with the Archaeological Institute of America.

February 3: Flagships of the Desert

Lecture at 7:30 p.m.

The extinction crisis in the Sahelo-Saharan region of North and West Africa has already cost the world one magnificent species in the wild—the scimitar-horned oryx—and threatens to cost us others. Zoo and wildlife biologists are playing a pivotal role in halting the decline of this fragile desert ecosystem and in ensuring the recovery of its wildlife.



Erwin and Peggy Bauer/USFWS

Canada lynx (*Lynx canadensis*) star in a movie that will screen on March 17 at the Zoo.

National Zoo research veterinarian Steven Monfort will describe the geography, climate, habitats, and wildlife of the Sahara; threats to the survival of wildlife and habitat; and recent conservation progress.

February 10: The Blunt Arrow of Cupid

Lecture at 7:30 p.m.

Why do endangered carnivores struggle to reproduce in zoos? Low fertility, small litter size, mate incompatibility, and breeding failure are just some of the reasons. Zoo reproductive specialists Budhan Pukazhenthil and Katey Pelican will discuss the challenges facing captive breeding programs, and what zoos and reproductive specialists are doing to overcome them.

March 3: Studying and Saving Elephants

Lecture at 7:30 p.m.

National Zoo elephant Shanthi was the second Asian elephant in the world to be successfully artificially inseminated, resulting in the birth of Kandula. In general, elephants in zoos breed poorly or not at all. Elephants in North American zoo populations are not re-

producing fast enough to replace themselves, and few are being imported from the wild. Unless something is done, 50 years from now there may not be elephants in zoos. National Zoo scientist Janine Brown will talk about the studies she and other Zoo scientists are conducting on Asian elephants to understand their unique biology, enhance their welfare in zoos, and improve their chances of successful reproduction.

March 17: *Walking With Ghosts*

Film screening at 7:30 p.m.

In cooperation with the D.C. Environmental Film Festival, we will screen *Walking With Ghosts*, a beautiful film. It documents the work of Elizabeth Hofer, a predator biologist who has dedicated more than 18 years to tracking the intricate relationship between the elusive lynx and its prey, the snowshoe hare. Filmed in Canada's boreal forest, *Walking With Ghosts* includes stunning footage of rarely seen lynx, from intimate moments of a lynx sleeping in a snow storm to a starving lynx hunting for voles. *Walking With Ghosts* was produced by acclaimed filmmaker Caroline Underwood.

THE SONORAN DESERT BY ALEX HAWES HANGS in the BALANCE

The saguaro flowers unfurl in darkness only minutes before a shadowy visitor approaches the cactus' curving arm and dips her snout into the pungent white petals. She is a lesser long-nosed bat, and she is pregnant. Already, the expectant mother has traveled more than a thousand miles, following a corridor of blossoming saguaro, cardón, and organ-pipe cacti from southern Mexico northward to Arizona's Organ Pipe Cactus National Monument. She will soon give birth to a single offspring inside an abandoned mine tunnel where she roosts. When her baby learns to fly, and the saguaro and organ-pipe fruits drop and wither under the blistering summer sun, she and thousands like her will continue east across the desert to feast on agaves in adjacent mountain ranges before journeying south again for winter.

The Sonoran Desert's landscape is as diverse as the plants and animals that live on it. Every globally recognized ecological community is present in the Sonoran Desert except for tundra, which occurs about 65 miles north of the desert. Even tropical forests thrive here.





As nighttime arrives in Saguaro National Park, nocturnal animals emerge into the cool air to search for food and mates.

An estimated 100,000 lesser long-nosed bats (*Leptonycteris curasoae*) converge on southeastern Arizona in late summer for the agave bloom, and an even larger number feed on agaves not far south, in the Mexican state of Sonora. These gray and cinnamon-brown creatures are valuable pollinators of the cacti and agaves they frequent, but their long-term survival is imperiled on both sides of the international border.

Lesser long-nosed bats were declared an endangered species in 1988. Conversion of their desert-scrub habitat by livestock grazing is just one cause. In Mexico, the moonshine tequila industry's demand for agaves is driving a decline in this vital resource for bats and other pollinators. In Arizona, the most immediate threat to the bats is the lack of viable maternity roost sites, according to Yar Petryszyn, a curator of the University of Arizona's mammal collection. Only four of these roost sites are known to exist in the entire state, most likely because of human disturbance. In the 1960s, for example, a huge ventilation fan blocked bats' entry and exit from Colossal Cave, a tourist attraction southeast of Tucson, and the bats abandoned their roost there. More recently, border crossers

used a roosting cave as a hideout and drove away a colony of bats west of town. "If bats are threatened with people visiting too much, then you are going to lose large numbers of bats," says Petryszyn.

The bats are just one of many species struggling to cope with changes in their Sonoran Desert home. But defenders of the desert seek to conserve not only the stark beauty and acclaimed wildlife of the Sonoran—from its famed rattlers and roadrunners (*Geococcyx californianus*) to critically endangered species such as the Sonoyta mud turtle (*Kinosternon sonoriense longifemorale*), whose U.S. population has dwindled to 130 individuals. More broadly, people are seeking balance between habitat and development, rivers and ranching, and consumption and conservation.

Blanketing more than 100,000 square miles, the Sonoran Desert stretches from the Mexican state of Sonora into southern Arizona, southeastern California, the Baja Peninsula, and the islands of the Gulf of California (Sea of Cortez). Illegal immigration joins an ever-growing list of challenges for protectors of this spellbinding landscape, a list that includes an exploding human population, a plunging water table, and an invasion of exotic species.



A lesser long-nosed bat draws nectar from an agave blossom.

Bruce Coleman Inc./John H. Hoffman

One Arizona community, Pima County, last spring passed a landmark, \$174.3 million open-space bond measure that has united environmentalists, biologists, developers, and hunters in pursuit of compromise between humans and nature. People have begun to recognize not just their impact on the desert, but the desert's cultural, spiritual, and economic impact on them.

From the evening cries of quail to the pungent odor of creosote after a late-July torrent, the Sonoran breathes with a vitality few outsiders can envision when conjuring the word "desert." Most think "deserted." Yet this preconceived image of a lifeless expanse, absent animals, absent verdure, may come to pass as the collective efforts of ranchers, miners, builders, and just plain folks to make a life in the Sonoran take their toll, bit by bit, on the fragile landscape.

Interrupting the Flow

Geronimo's surrender at Skeleton Canyon, Arizona, in 1886 signaled the United States' final conquest of the Western frontier. Fifty years later, the completion of Hoover Dam across the Colorado River's Black Canyon signaled a similar conquest of the environment.

Hoover Dam, and less heralded dams on the Colorado River and its tributaries, provided hydroelectric power to draw settlers to the Southwest while preventing flooding and easing irrigation. Following the completion of Roosevelt Dam in 1911, the Salt River Valley became a major cotton producer. Meanwhile, advanced pumping technology put progressively greater strains on water tables in Arizona and in Sonora, Mexico. By the 1980s, rivers that flowed year-round were flowing only seasonally, and some rivers that flowed seasonally rarely flowed at all. "The Colorado and its tributaries, along with the other major rivers that brought water to the Sonoran Desert, such as the Yaqui and the Mayo, became ghosts of the past, victims of the twentieth century, carcasses of sand whose lifeblood had been diverted into cotton fields, copper mines, and vast, sprawling cities," writes Thomas Sheridan of the Arizona State Museum in *A Natural History of the Sonoran Desert*.

The wildlife of the Sonoran Desert has proven remarkably adapted to the adversity of heat and drought—but tragically unprepared for the novelty of agriculture and urbanization. Most directly threatened by people meddling with the desert's plumbing are the Sonoran's

resident fish. The changing flows of rivers managed according to electrical demand rather than fish biology have created stream conditions below dams that favor non-native fish species. Today, exotic species—most introduced for game fishing—outnumber native species two to one. These outsiders often outcompete or even prey upon Arizona's native fish, two-thirds of which are now listed as either threatened or endangered, the highest percentage of any state.

The Gila topminnow (*Poeciliopsis occidentalis*), a prolific breeder that was once common in the Southwest, has been heavily preyed upon by the mosquitofish (*Gambusia affinis*), a species introduced from the Mississippi Basin for mosquito control. At the other end of the spectrum, the Colorado River squawfish (*Ptychocheilus lucius*), which can grow to six feet long and more than 80 pounds in weight, is endangered because dams disrupt its reproduction: Seasonal flooding normally cued the fish to spawn. The squawfish and other big river desert fish have humps behind their heads—"like a sportscar," says Kieran Suckling of the Center for Biological Diversity—that push them toward the riverbottom and thereby stabilize them amid powerful currents. Non-native fish lack the hump and would get swept away during a monsoon. Yet as dams hold back summer

floods, native fish can't drive off alien invaders. Squawfish were once so common that farmers speared them from streams with pitchforks to fertilize their fields. They are now nearly extinct in Arizona.

Tapping the region's water not only imperiled fish; it set off a series of catastrophic ecological consequences that reverberate along the Sonoran Desert's waterways, affecting wildlife of all stripes. As pumping technology has enabled aquifers to be more effectively exploited, the region's water table has dropped an average of 160 feet and as much as 1,000 feet in some areas.

The wildlife of the Sonoran Desert has proven remarkably adapted to the adversity of heat and drought—but tragically unprepared for the novelty of agriculture and urbanization.



With a centipede in its beak, an elf owl (*Micrathene whitneyi*) deftly alights on its nest amid the spines of a saguaro.

Bruce Coleman Inc./Mervin W. Larson

THE LONG ARM OF THE SAGUARO

As an image on keychains or a prop in cowboy westerns, the saguaro (*Carnegiea gigantea*) symbolizes the Southwest more than any other species. keystones of the desert ecosystem, saguaro cacti are unique to the Sonoran, their range further confined to elevations between sea level and 4,000 feet because they are intolerant of freezing temperatures.

A young saguaro develops under the indifferent but indispensable care of a nurse tree, most often a palo verde (*Cercidium* spp.), desert ironwood (*Olneya tesota*), or mesquite (*Prosopis* spp.). The nurse tree shelters the saguaro from extreme heat and frost, and from foraging animals. It takes 25 years on average for the cactus to grow a foot high. As it matures and develops its first arms at between 50 to 100 years of age, the saguaro may sap enough water and nutrients from the surrounding soil to kill off its aging nurse.

Saguaros grow two to 50 arms, which can twist, due to frost damage, into bizarre contortions. The roots of this succulent plant penetrate no more than four inches into the soil, yet they spread as wide as the plant is tall. Fully grown saguaros may tower 50 feet and weigh six tons—of which 90 percent is water.

These prickly giants lord generously over the ecosystem around them. Hawks and owls use saguaro column tops as sentry points to peer for prey across the wide expanse of the desert. Red-tailed hawks (*Buteo jamaicensis*) also build nests in the crooks of the saguaros' arms. Gilded flickers (*Colaptes chrysoides*) and Gila woodpeckers (*Melanerpes uropygialis*) hammer nesting cavities right into the sides of saguaro, causing the cacti's walls to seal with scar tissue. When the cacti die and disintegrate, the hardened scar tissue remains in a hollow shape called a "saguaro boot." (Seri Indians from the arid coast of Sonora, Mexico, use these boots to carry and store water.) Flickers and woodpeckers abandon saguaro cavities after a year, allowing elf owls, purple martins (*Progne subis*), and other birds to move in. The cavities remain relatively cool during the day and warm at night, offering relief from the desert's temperature extremes.

Creamy-white flowers blossom on saguaros in late spring. Individual flowers begin opening after sunset and are fully unfurled by midnight, then close by the following afternoon, never to open

again. Lesser long-nosed bats and Mexican long-tongued bats (*Choeronycteris mexicana*) use their elongated muzzles to reach deep into saguaro blossoms for nectar. During the day, the saguaro flowers are visited by wasps, bees, butterflies, and birds.

Once the saguaro fruit ripens in June, lesser long-nosed bats, white-winged doves (*Zenaida asiatica*), Gila woodpeckers, and other birds consume the fleshy red pulp and thereby disperse the seeds, which pass through their guts intact. A host of mammals, including

Harris antelope squirrels (*Ammospermophilus harrisi*), cactus mice (*Peromyscus eremicus*), skunks (family Mustelidae), and coyotes (*Canis latrans*), gobble up saguaro fruits that fall to the desert floor. For centuries, the Tohono O'odham people have used long poles made from the ribs of the cactus to harvest saguaro fruit, which they make into syrups, jams, and ceremonial wines.

Saguaros seem to be perfectly evolved for pollination by bats, according to Mark Dimmitt of the Arizona-Sonora Desert Museum. Their flowers bloom high in the air, open at night, produce copious nectar and pollen, and smell like an overripe melon. Yet research conducted at Kino Bay, along the coast of Sonora, Mexico, suggests that lesser long-nosed bats prefer organ-pipe and cardón cacti to saguaros, although in southern Arizona, a region where few organ-

pipe and no cardón cacti grow, lesser long-nosed bats depend much more heavily on saguaros for sustenance. Most saguaros are likely pollinated by bees and white-winged doves, species that feed during the day. Scientists are puzzled by this pollination paradox. "Have we encountered the early stage of an evolutionary shift?" writes Mark Dimmitt in *A Natural History of the Sonoran Desert*. "In 100,000 years will saguaros have diurnal yellow flowers [to better attract bees and birds]? Or do the bats still have sufficient, yet-unknown influence on saguaro evolution to maintain the status quo?" Perhaps the saguaros know, but they aren't talking.



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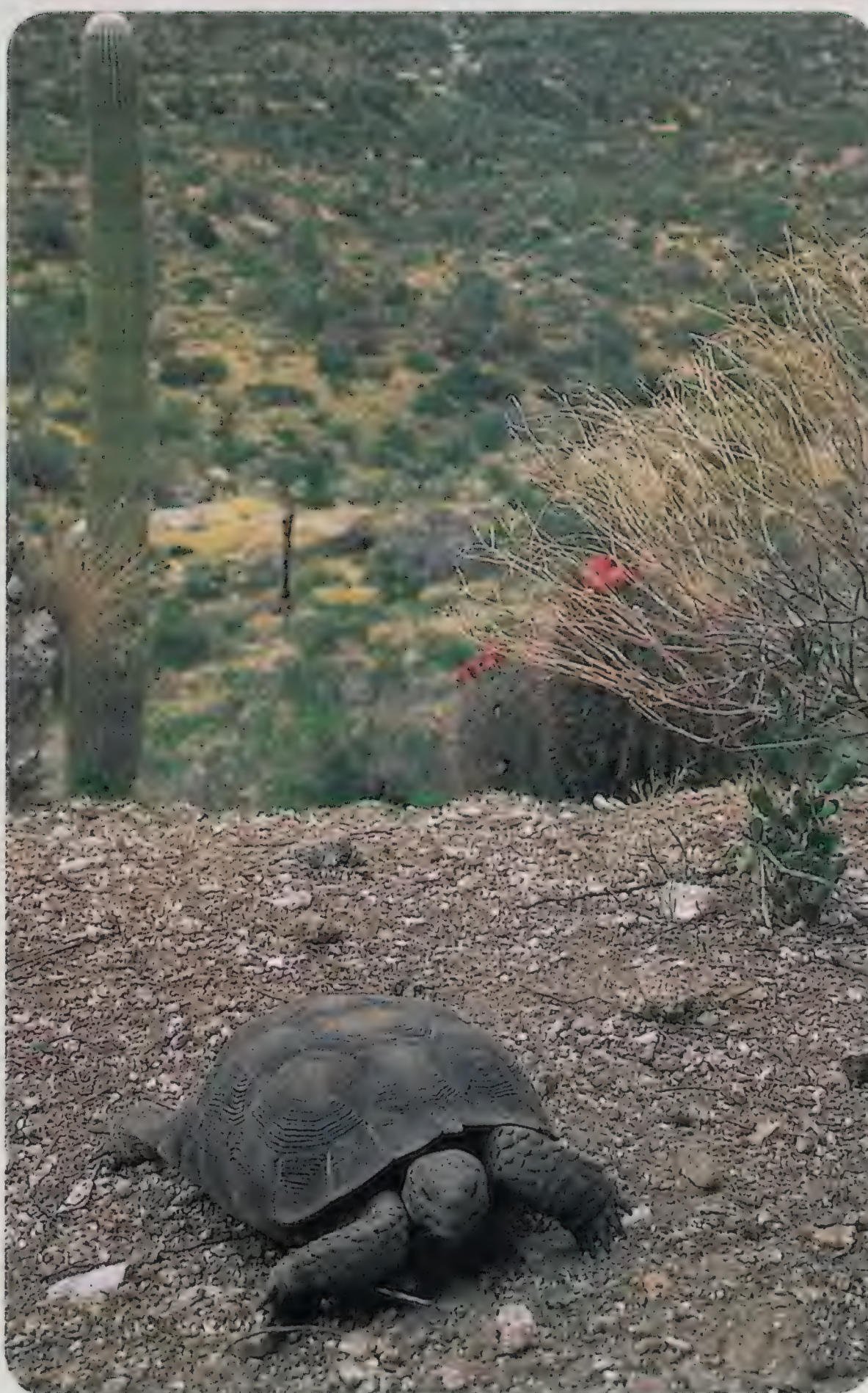
That drop puts the water table beneath the root zone of many riparian trees, including Fremont cottonwoods (*Populus fremontii*) and Goodding willows (*Salix gooddingii*). Cottonwood-willow complexes are now one of the rarest forest types in the U.S., according to The Nature Conservancy. An estimated 90 percent of the Sonoran's riparian forest—lands adjacent to rivers, lakes, and other aquatic habitat—has disappeared due to groundwater pumping and irrigation. In turn, riparian-living animals, from Mexican garter snakes (*Thamnophis eques megalops*) and Chiricahua leopard frogs (*Rana chiricahuensis*) to western red bats (*Lasiurus blossevillei*), have become increasingly threatened.

More than 85 percent of all Sonoran Desert animals rely on riparian areas at some stage of their life. The San Pedro riparian corridor, which runs 140 miles from its source in the Los Altos and Mariquita mountains in Sonora, Mexico, north to Arizona's Gila River, nourishes about 250 migratory bird species, 80 mammal species, and 45 reptile and amphibian species. Elegant trogons (*Trogon elegans*)—striking, emerald-headed birds with crimson breasts—forage for insects and fruit above the river's banks, while coatis (*Nasua narica*) nose about the leaf litter for grubs, worms, and lizards in bands of up to 20 or more.

One of only two rivers to flow north from Mexico—and one of the last undammed rivers in the Southwest—the San Pedro offers particularly critical habitat for the southwestern willow flycatcher (*Empidonax trillii extimus*). Fewer than 1,000 breeding pairs of this white-throated, olive-brown bird remain in isolated populations across southern Colorado, New Mexico, Arizona, and southern California. Identified by its characteristic “fitz-bew” call, the bird favors dense riparian vegetation—habitat at a premium these days. Declared an endangered species in 1995, the southwestern willow flycatcher is facing off with yet another uninvited guest in

the region: the brown-headed cowbird (*Molothrus ater*), which lays its eggs in the nests of at least 100 bird species, often destroying the eggs already there. Occasionally, a mother might successfully raise both her young and the interlopers, but not in the case of willow flycatchers: A cowbird invasion results in either complete nest failure or the rearing only of cowbird chicks.

Fortunately, steps are being taken to protect the vital habitat that has survived a century of ranching and water diversion.



Devastating fires can sweep through desert tortoise habitat, killing any slow-moving animals in their wake. The fires are fueled by non-native grasses.

Grazing and Blazing: Invasive Species

Yet nothing jeopardizes riparian habitats and the species they shelter, according to many conservationists, more than the animals for whom cowbirds are named. Cows graze greedily upon small saplings and thereby prevent the healthy growth of riparian stands. According to Sheridan, 37,000 cattle roamed Arizona in 1870, but by the turn of the century, following the securing of the Southwest for American frontiersmen, about 1.5 million cattle and one million sheep had been herded into the state.

Fortunately, steps are being taken to protect the vital habitat that has survived a century of ranching and water diversion. The San Pedro Riparian National Conservation Area, created in 1988, safeguards 43 miles of the river's banks from grazing and other harmful activities. The U.S. Forest Service has stopped public grazing near more than 250 miles of federally owned streams in southern Arizona and New Mexico to protect willow flycatcher habitat. “Since the cattle have been removed, it's like a jungle!” exclaims Suckling about some of the sheltered stretches of river he's rafted recently, adding that deeper streams resulting from

fortified riverbanks offer excellent native fish habitat as well.

Elsewhere, however, the impact of grazing spreads unimpeded. Ranchers across the region have planted exotic grasses to feed their stock. Conservation International estimates that more than half of the entire Sonoran Desert is now covered by nearly 400 alien

plant species. A few species—buffelgrass (*Pennisetum ciliare*) and Lehmann lovegrass (*Eragrostis lehmanniana*) from Africa, and red brome (*Bromus rubens*), a species first brought from the Mediterranean to California in 1848—have predominated. In central Sonora, Mexico, ranchers have cleared more than a half-million acres of desert to plant buffelgrass, some with Mexican government funding.

Exotic grasses have spread across the desert, literally, like a wildfire. Old World grasses thrive after—and even encourage—fire, in stark contrast to the desert-scrub and tropical deciduous forest species native to the Sonoran Desert, which evolved essentially free from flames. Early summer wildfires in the Sonoran, fueled mainly by red brome, have become more than ten times more frequent over the past decade. While red brome is providing a new food source to desert tortoises (*Gopherus agassizii*), these slow movers often cannot escape the blazes it creates. Tom Van Devender, senior research scientist at the Arizona-Sonora Desert Museum, attests that exotic grass species have converted much of Mexico's Sonoran desert-scrub region into a grasslands landscape reminiscent of the African savanna—without the animals. “The loss of wildlife is tremendous,” says Van Devender. “You hardly ever see a diamond-back rattlesnake [*Crotalus atrox*],” a species practically synonymous with the Sonoran Desert.

A Developing Problem

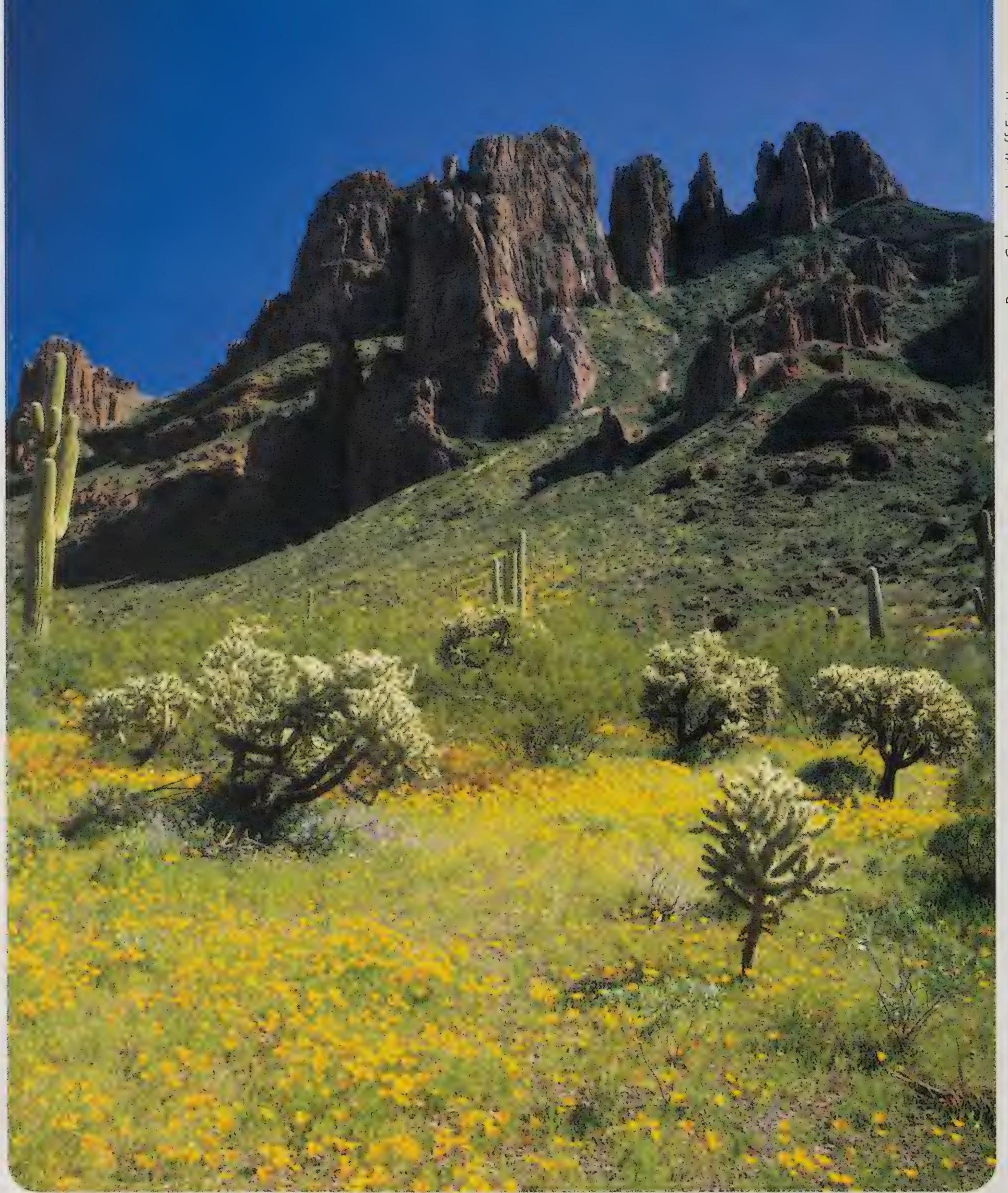
More than alien weeds, it is people who have conquered the Sonoran Desert, and who are arriving every day to lay claim to its spoils. The region's settlement has shifted from more than one-half rural to more than three-quarters urban since World War II, according to Gary Nabhan and Andrew Holdsworth's *State of the Sonoran Desert Biome*. Between 1970 and 1990, the populations of the desert's twin capitals—Hermosillo, Sonora, and Phoenix, Arizona—each more than doubled. The trend shows no signs of slowing: Maricopa County, which includes Phoenix and already claims more residents than 20 U.S. states, has been forecast to grow 250 percent between 1995 and 2025.

Highways, subdivisions, golf courses, irrigation canals, and other outgrowths of Sunbelt civilization have sliced the Sonoran

into isolated islands of vestigial habitat. New construction in Pima County, a sprawling district reaching from Tucson south to the border, eats up an acre of desert every two hours. Tucson's rapid growth has already harmed one hardy mammal, the desert bighorn sheep (*Ovis canadensis*), now vanished from the Pusch Ridge, Rincon, and Catalina ranges that overlook the Old Pueblo. Superbly adapted to the desert, bighorn are suffering from habitat fragmentation, disease spread by domestic goats, and deadly fires that have grown out of control following years of fire suppression by the U.S. Forest Service, according to Paul Krausman, a wildlife biologist at the University of Arizona. “In a nutshell, wilderness species don't do well with economic development,” says Krausman.

Defending a Desert, Sonoran Style

Into the tussle over water, livestock, and land flew a tiny, reddish-brown bird—the cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*). It has served as an improbable catalyst to unite the defenders of development and the defenders of the desert. Standing a mere seven inches tall, the fierce pygmy-owl preys upon insects, lizards, and even other birds. Historically, the owl has preferred



The Sonoran Desert defies the stereotype that deserts are barren and lifeless. At Organ Pipe Cactus National Monument, Mexican poppies (*Eschscholzia californica*) and teddy bear cholla (*Opuntia bigelovii*) bloom.

mesquite-cottonwood riparian thickets below 4,000 feet. As its habitat vanished and the owl's numbers declined, however, the nocturnal hunter was forced into ever-greater proximity with people.

A survey in 2001 found only 36 cactus ferruginous pygmy-owls in Arizona, primarily in three locations: Tucson's quickly developing Northwest Side, the Altar Valley southwest of the city, and Organ Pipe Cactus National Monument along the Arizona-Mexico border. A population of 280 pygmy-owls was also found in Mexico's Sonora—including 26 within six miles of the international border, which could eventually bolster Arizona's ranks—while an eastern population occupies southern Texas and adjacent portions of Mexico.

On March 10, 1997, nearly five years after it was first petitioned to list the cactus ferruginous pygmy-owl, the U.S. Fish & Wildlife Service declared the owl's Arizona population endangered. The move could have set off a turf war in southern Arizona between conservationists and developers. Instead, the listing prompted the Pima County Board of Supervisors in 1998 to create the Sonoran Desert Conservation Plan (SDCP), a bold measure that is joining traditional foes to fashion a sustainable future for wildlife and city life.

"Like many western communities, Tucson has rejected meaningful land-use planning [in the past]," says William Shaw, a profes-

sor in the University of Arizona's School of Renewable Natural Resources and chair of the SDCP's Science and Technical Advisory Team. "The pygmy-owl listing was the hammer."

Initially, the listing disrupted the construction of homes, roads, and even a new high school in Northwest Tucson. However, the county sought to take advantage of the Endangered Species Act's controversial Section 10, a statute

that eases certain restrictions of the Act as long as a municipality creates a comprehensive habitat conservation plan for the greater good of the threatened species. Pima County officials saw beyond the need to salvage land for the pygmy-owl, though. They seized the moment to build a future for the surrounding Sonoran Desert and its threatened wildlife for decades to come.

Members of the SDCP's Science and Technical Advisory Team were charged with not only designating habitat to protect the pygmy-owl, but mapping out an interconnected system of lands—which Pima County could purchase over time—that would protect the desert ecosystem as a whole and put a brake on sprawl in the metropolitan region. For five years, scientists worked to compile a list of 55 "priority vulnerable species" that were particularly imperiled by future development in the county. By preserving habitat for these selected species, planners would inevitably aid plants and animals not chosen as well.

Making the list: familiar faces such as the pygmy-owl, the southwestern willow flycatcher, and the lesser long-nosed bat, as well as the Pima pineapple cactus (*Echinomastus erectocentrus*)—a small, endangered plant that some have called "the next cactus ferruginous pygmy-owl" for its potential to disrupt construction. Absent from the list were endangered species like the jaguar (*Panthera onca*) and the Mexican spotted owl (*Strix occidentalis lucida*) that either range primarily outside Pima County or on protected federal lands, and for whom purchasing acreage would have little impact. Male jaguars, which can roam distances up to 500 miles, are spotted north of the

Desert bighorn sheep were driven from their native habitat in the Tucson area by development, invasive species, and wildfires.



When the ferruginous pygmy-owl became endangered in 1997, officials in Pima County, Arizona, drafted a large-scale conservation plan.

Bruce Coleman Inc./John Snyder



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Mexican border about once a year. "The jaguar's survival is not going to depend on Pima County's decision," says Shaw.

Some critics have raised issues with the composition of the list, noting that only eight of the 55 species are federally designated as endangered. Proponents of the SDCP hope that the county's actions will prevent these species from reaching that point, saving the local government and private landowners years of headaches and considerable legal expense, while preserving clean air and clean water for the entire community through the protection of healthy habitat.

Scientists divided the 5.9 million acres covered by the SDCP into a grid of color-coded polygons according to how many of the 55 vulnerable species each polygon may contain. Polygons with habitat suitable for five or more species—frequently along riparian areas—became "biological cores" in the most urgent need of protection. The SDCP's planners also devised corridors of land linking already established reserves to extend the range of protected wildlife much farther.

The map became a wish list for conservationists hoping to secure the Sonoran for centuries to come. All that was needed was money. On May 18, by a two-to-one margin, Pima County voters approved a \$174.3 million open-space bond, of which \$112 million would fund "habitat protection priorities"—land specifically targeted for biodiversity conservation by the SDCP. Development will certainly continue—there's no damming the flood of people into the Southwest from all corners of the continent—but conservationists hope new construction will shift onto less biologically valuable land.

The SDCP, which has won a host of regional and national planning awards, is serving as a model for land-use schemes elsewhere. "The Tucson population is not as unique as we think of ourselves," says William Shaw. "Communities all over want to do what we're

doing." He points to efforts to restore the Los Angeles River as an example. "Well, we may be unique compared to Phoenix!" he jokes. The inexorable rise of metropolitan Phoenix long ago eliminated species such as the cactus ferruginous pygmy-owl from its urban core.

Without endangered species listings, there has been no regulatory hammer to drive developers and conservationists to work together, and so Phoenix lacks a long-range plan akin to that of its southern neighbor.

Yet as long as there are people drawn to live in the desert, there will be people drawn to protect it. Nearly 150 miles west of Tucson, Sue Rutman tackles the buffelgrass invasion at Organ Pipe National Monument single-handedly. She is the lone botanist in a park more than seven times the size of the District of Columbia. There's been scarcely any rain this year, leaving Rutman to wonder whether the organ-pipe cacti will provide enough fruit for the lesser long-nosed bats. She frets too that the hundreds of border crossers and smugglers streaming into the park each week by foot and crashing through by car—and the Border Patrol agents chasing after them—may be spooking the 20 Sonoran pronghorn (*Antilocapra americana sonoriensis*) left in the U.S. that occasionally wander into the park in search of cholla. Still, she remains upbeat.

"Organ Pipe Cactus National Monument is 517 square miles. There's no way that all that is going to be damaged, and so there's an awful lot of re-

search going on that is illuminating aspects of the human-occupied world. That's one of the reasons we need open space," says Rutman.

"Another reason is that I need to breathe!" Z

—Alex Hawes planted his own alien roots in Tucson two years ago, dreaming of warm winters and never-ending skies.

Pima County voters approved a \$174.3 million open-space bond, of which \$112 million would fund "habitat protection priorities."



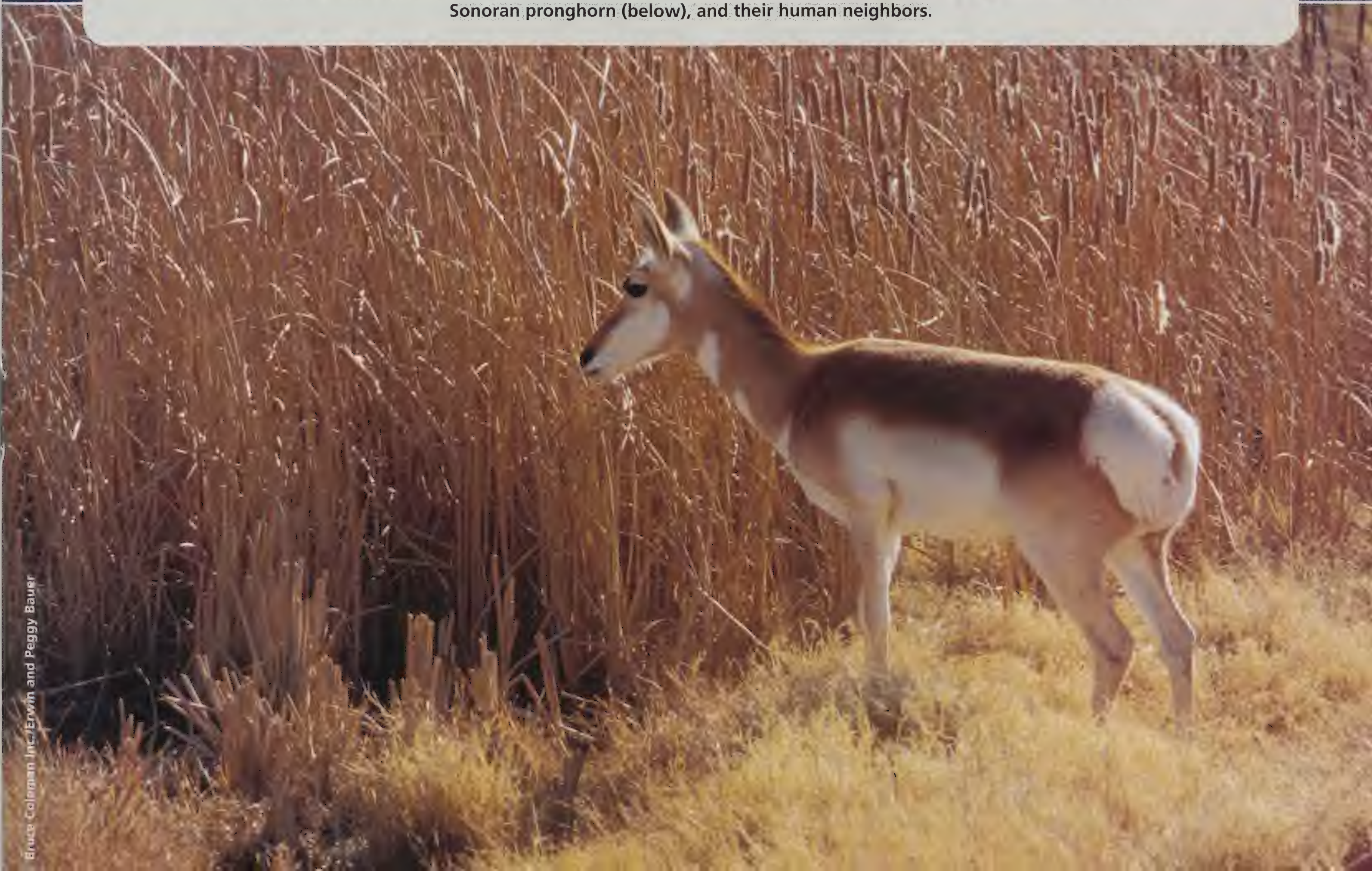
In the Sonoran Desert, even harsh-looking plants have beauty and purpose. Prickly pear cactus (*Opuntia* sp.), for example, nourish mammals and insects.

Bruce Coleman Inc./Jen and Des Bartlett



Bruce Coleman Inc./Keith Gunnar

A comprehensive conservation plan could benefit all Sonoran Desert species, including saguaro cacti (above), Sonoran pronghorn (below), and their human neighbors.



Bruce Coleman Inc./Erwin and Peggy Bauer

SURVIVING THE SONORAN

The Sonoran is one of four North American deserts. The others are the Chihuahuan, the Mojave, and the Great Basin. Of the four, the Sonoran is the lowest in elevation, the most moist, and, as a transition zone to subtropical ecosystems to the south, the most biologically diverse.

From July to September, the monsoon season delivers humid, tropical air and occasional violent afternoon and evening thunderstorms to the Sonoran. These monsoonal rains, which the neighboring Mojave Desert lacks, reduce the severity of the desert's extreme summer heat. Gentler rains generated by frontal systems from the Pacific create a secondary rainy season from December to March. Tucson, on the eastern side of the desert, receives an average of 12 inches of annual rainfall. However, westward toward the Colorado Delta, below Yuma—where air temperatures in summer can approach 120°F and surface temperatures 200°F—rainfall dips to a mere three inches per year. Some years, no rain falls at all.

Plant and animal life flourishes across the desert despite the challenges of heat and water. The Sonoran Desert is home to about 30 species of native freshwater fish, 100 reptile species (many found nowhere else), 60 mammal species, 350 bird species, and 2,000 plant species. The rainbow bloom of flowering plants in the spring and summer draws an incredible spectrum of pollinators, including the greatest diversity of hummingbirds and butterflies in the United States. Within a 30-mile radius of Tucson buzz as many as 1,200 species of bees—from the world's smallest, *Perdita minima*, which measures less than two millimeters (0.08 inches) across, to 1.5-inch-long carpenter bees (*Xylocopa* spp.).

Water dictates life in the desert. Most desert plants, like the ocotillo (*Fouquieria splendens*), bear miniature leaves—an evolutionary trait known as microphylls—to reduce water loss and prevent overheating. Three hundred of the world's 1,800 cactus species occur in the Sonoran Desert, and like all cacti and many other desert plants, they store water in their leaves, stems, and roots. But this adaptation also makes these "succulents" attractive to foraging animals that rely on plants for water when standing water is unavailable. As the temperature rises, animals need more and more water to survive, yet less and less water is available—what biologist Peter Siminski of the

Arizona-Sonora Desert Museum calls a "desert catch-22." Most succulents have spines to deter desperate raiders and to shade themselves from the deadly heat of the sun. The teddy bear cholla is so blanketed in spines that it looks fuzzy—but don't make the mistake of snuggling up to it!

Some animals don't mind the spines. Mourning doves (*Zenaida macroura*), thrashers (*Toxostoma* spp.), cactus wrens (*Campylorhynchus brunneicapillus*), and roadrunners build nests in prickly pear and cholla to evade predators. The nettlesome spines do little to dissuade packrats (*Neotoma albigula*), jackrabbits (*Lepus* spp.), and especially javelinas (*Pecari tajacu*) from consuming the juicy pads of prickly pears voraciously,



In the Sonoran Desert, surface temperatures can reach almost 200°F. Desert iguanas' (*Dipsosaurus dorsalis*) bodies are built to tolerate the extreme heat.

spines and all. These animals' digestive systems can cope with the cacti's high concentrations of oxalic acid, which is toxic to other animals. Another prickly pear eater is the cochineal bug (*Dactylopius* spp.), an insect whose body fluids contain a crimson, foul-tasting substance first used by indigenous Americans to dye textiles. Cochineal has immense commercial value and is used in everything from candies to lipstick.



Bruce Coleman Inc./C.C. Lockwood

A javelina forages through a patch of prickly pear cactus for a meal. Unlike most mammals, javelinas, jackrabbits, and packrats are able to digest the toxic acids in prickly pear and agave cacti.

Amphibians, so reliant on water, have evolved several adaptations to survive the Sonoran. Couch's spadefoot (*Scaphiopus couchii*), the northern casque-headed frog (*Pteronohyla fodiens*), and the Sonoran Desert toad (*Bufo alvarius*) dig as many as three feet underground and remain in a hole for nine to ten months each year, then emerge with the summer rains to feed and breed in temporary ponds. Following breeding, Couch's spadefoot eggs may hatch within 15 hours and metamorphose into froglets about two weeks later, before the ponds disappear.

Reptiles that travel by day must heed the position and intensity of the sun. They scurry in and out of the shade, lift their bodies high off the hot ground, and turn toward and away from the sun to regulate their temperatures. Some have skin that darkens to absorb heat more efficiently. Desert iguanas, which lurk in arid, creosote-covered lowlands even during the hottest times of summer, can tolerate internal body temperatures as high as 108°F.

In contrast, the Sonoran Desert's legendary rattlesnakes (the region contains more rattler species than any other region in the world) can't tolerate extreme heat, and bask in the sun only when the air temperature hovers between about 70° and 90°F. In summer, they hunt at night to avoid the heat of the day. The Mojave rattlesnake (*Crotalus scutulatus*), commonly found in the desert grasslands

of southeastern Arizona, has the greatest potential to harm humans; it is more unpredictable and more venomous than its mellower cousins. The shy Gila monster (*Heloderma suspectum*), one of only two venomous lizards in the world, is inactive from July through March, but emerges in the spring to search for bird eggs and baby quail at night.

I have encountered rattlers, Gila monsters, tarantulas, and scorpions, but nothing startled me quite so much as when I reached to open the screen door to the backyard and found myself eye to eye (or, rather, two eyes to eight eyes) with a giant

crab spider (*Olios giganteus*), a dextrous creature with a leg span up to 2.5 inches that is able to scurry in any direction up rock faces, saguaros—and screens—in search of prey. I liberated the arachnid, which has a nasty bite but is otherwise harmless to people, rather than yield to my urge to squish it. Although nearly all spiders carry venom, in Arizona only the black widow (*Latrodectus hesperus*) and brown spider (*Loxosceles* spp.)—species certainly not unique to the desert—are considered potentially deadly to people. The venom of the Sonoran Desert's tarantulas can cause pain and swelling but poses little danger unless a person is allergic. Male Arizona blond tarantulas (*Aphonopelma chalcodes*) are frequently spotted at night on Tucson roads during the monsoon season as they search for mates.



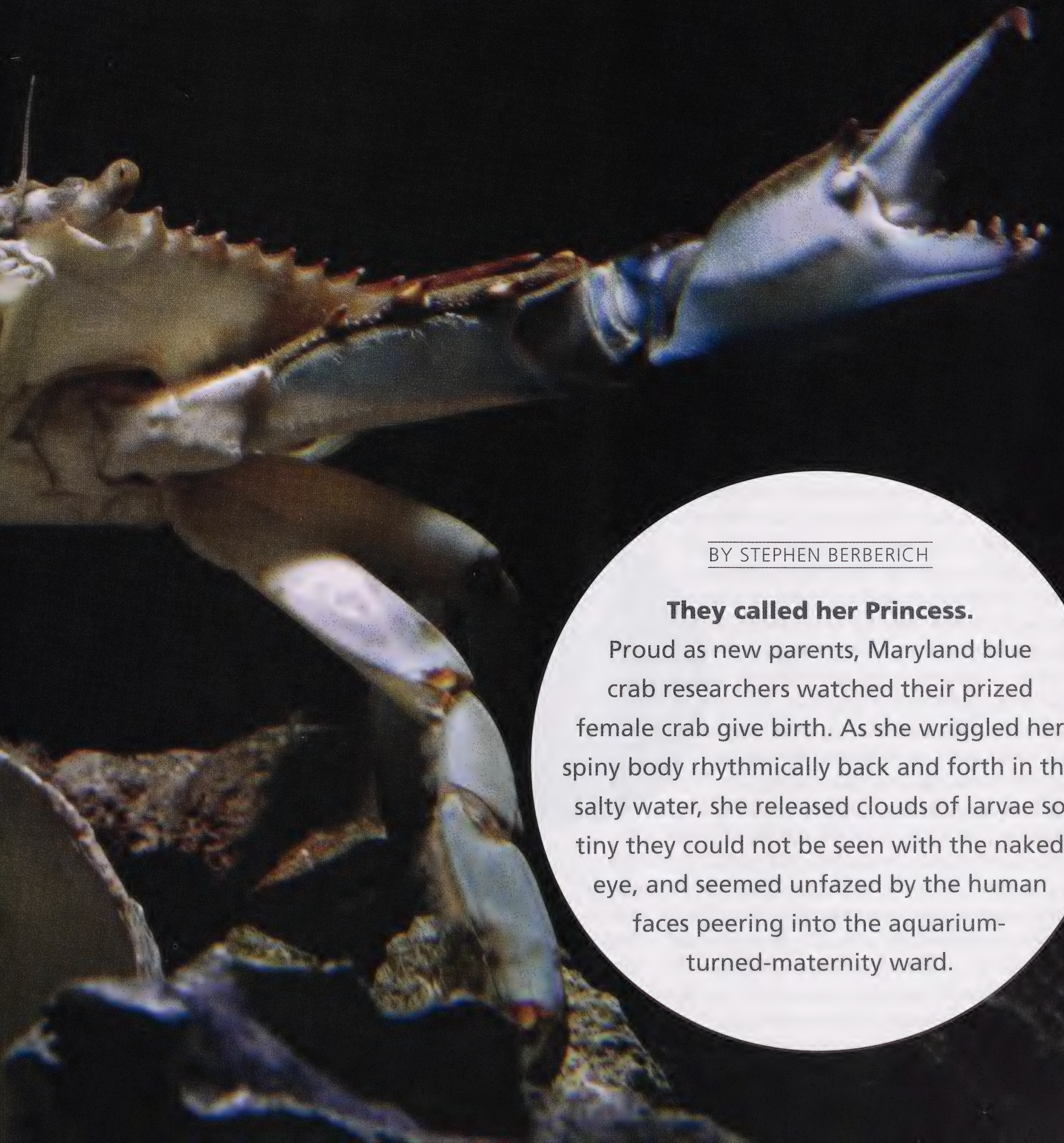
Chollas and other cacti defend themselves against hungry animals with a coating of sharp spines.

—Alex Hawes

Hatching a Plan

The National Zoo's Blue Crab and the Bay exhibit showcases the Smithsonian's efforts to revitalize blue crab populations in the Chesapeake.

for Blue Crabs



BY STEPHEN BERBERICH

They called her Princess.

Proud as new parents, Maryland blue crab researchers watched their prized female crab give birth. As she wriggled her spiny body rhythmically back and forth in the salty water, she released clouds of larvae so tiny they could not be seen with the naked eye, and seemed unfazed by the human faces peering into the aquarium-turned-maternity ward.



The Chesapeake Bay once contained a great bounty of blue crabs, but they are no longer proliferating. Smithsonian scientists are working to find out why—and how to create a sustainable future for the crabs.

In the Chesapeake Bay, blue crabs (*Callinectes sapidus*) hatch in the spring and summer. A mother crab shakes off larvae, called zoea, that emerge from a spongy apron of eggs attached to the underside of her hard-shelled body. But Princess' laboratory hatching happened in winter, on February 14, 2002. Her admiring researchers had been adjusting the water conditions in her tank for several weeks to encourage her to hatch early, at an experimental blue crab hatchery at the University of Maryland's Center of Marine Biotechnology (COMB) in Baltimore.

Blue crab numbers are declining in the Bay, and suffered an 85 percent drop in population since 1990. Increasing development and agricultural runoff are part of the problem. When nutrients from eroding soil and fertilizer wash into the Bay, algal blooms become more prevalent, killing off marine vegetation that provides blue crab habitat. A high demand for crabmeat is another factor: More than one-third of the United States' blue crab harvest comes from the Chesapeake, generating about \$50 million per year, the most valuable of all blue crab fisheries.

Fewer crabs could mean hard times for the local fishing industry and disruption of natural ecological cycles in the Bay. The decline has raised a high tide of federal, state, and private funding for the COMB hatchery and Smithsonian-led ecology studies to save the

blue crab. When watermen hauled in Princess with their harvest of commercial crab pots the previous fall, they donated her and several other healthy females to the Smithsonian Environmental Research Center (SERC) in Edgewater, Maryland, where scientists selected the best specimens for the COMB hatchery.

Ordinarily, a sweet name like "Princess" wouldn't fit a blue crab. She is one of the most fearsome looking species in the Bay, with large pinching claws and an aggressive, cantankerous attitude. But Yonathan Zohar, a leading fish reproductive endocrinologist and COMB director, put great significance on her Valentine's Day hatching. It was the first at the new hatchery and the climax of two months of anxious experiments.

Certainly his researchers had cause to mix some sentiment with science when they nicknamed her.

More than one-third of the United States' blue crab harvest comes from the Chesapeake, generating about \$50 million per year.

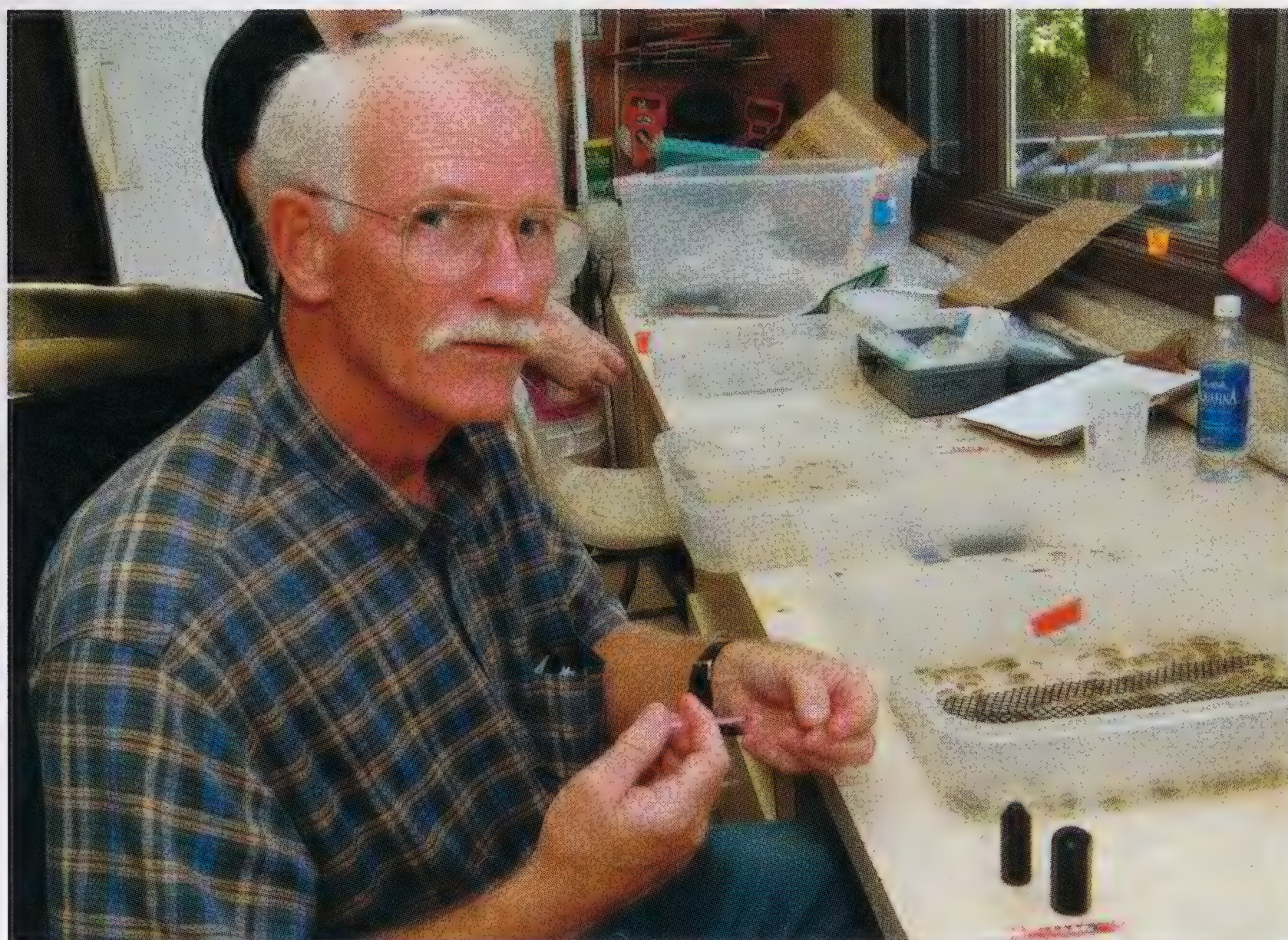
Blue Crab Enhancement Project

Princess and her first brood of zoea that day began what is now the largest tag-release-and-recovery crab study in the world, says Zohar. His COMB team nurtures blue crab hatchlings on a gourmet diet that includes minute shrimp and select species of algae. The larvae are raised in giant tanks of clean, disease-free water in a completely closed, pollution-free system a few yards from Baltimore's Inner Harbor.

Outdoor studies of Princess' hatchlings began May 6, 2002, when partnering scientists at SERC released thousands of her babies, each about the size of a quarter, into Chesapeake Bay waters. By the 2004 season, COMB was on a roll, producing more than 60,000 juveniles in captivity. Then, a Smithsonian team led by estuarine ecologist Anson Hines at SERC released half of the hatchlings into small coves of Boathouse Creek on the Rhode River, several miles south of Annapolis, Maryland. A second team of scientists at the Virginia Institute of Marine Sciences (VIMS), many of them former students of Hines', released the other half of the hatchlings for duplicate stud-

While some SERC and VIMS researchers monitor survival of COMB's crabs, others are assessing the Bay's potential carrying capacity for more blue crab releases. The results may help Maryland and Virginia set better crab harvesting regulations, perhaps based on whole ecosystem data, says Rom Lipcius, a marine conservation biologist at VIMS. The stark reality is that pregnant females that manage to survive a tough gauntlet of crab pots and reach spawning waters are no longer producing enough offspring to replenish the population, according to VIMS' annual trawling survey.

The scientists realize that to really help blue crabs, they have to get up close and personal with them.



Rich Strauss/SI

Anson Hines of SERC injects an elastomer into a juvenile crab so it can be identified later.

ies into coves of the York River near Williamsburg, Virginia.

The entire scientific effort is called the Blue Crab Enhancement Project and is featured in the Blue Crab and the Bay exhibit at the Smithsonian's National Zoo.

No one knows for sure yet if the enhancement project will help boost the numbers of blue crabs in the Chesapeake Bay. But Hines, a 25-year veteran of ecology studies of crabs and other benthic fauna, is optimistic. "Whether we are able to enhance the population on the scale of the Chesapeake Bay or not, this research is providing very valuable information about [blue crab] habitats, movement patterns, survivorship, reproductive success, and juvenile growth and development," he says.

By releasing COMB hatchery juveniles as 3/4-inch-wide juveniles rather than as zoea, blue crab researchers can skip the difficult task of tracking the crabs through the early, vulnerable stages of their life cycle. The COMB juveniles are also older than their wild counterparts when they are released into the shallows of the York and Rhode rivers, and are therefore better equipped to dodge predators.

The Life of a Princess

Blue crabs are bottom-feeding crustaceans that live primarily along the eastern coasts of North and South America, from Nova Scotia to northern Argentina. Their top shell, or carapace, is a gray-green or bluish green. Their characteristic bright blue claws are big and powerful tools, used for gathering food, digging for shelter, fighting, and for males, sexual posturing. They also have retractable eyes on little stalks that give them a nearly 360 degree range of vision.

Like most members of Portunidae, the swimming crab family, blue crabs evolved in tropical systems, but this species found a highly suitable home in the Chesapeake. Although not at the geographic center of blue crabs' range, the Bay is the largest estuary on the East Coast. Crab-friendly coves and salt marsh grasses line 4,600 miles of tidal shoreline, and the average water depth is only 18 feet, except for the mid-rib

channel—an ancient riverbed—that is about 80 feet deep. Watermen and scientists agree that the Chesapeake was an ideal habitat for blue crabs to thrive before human development.

Blue crabs' genus name, *Callinectes*, means "beautiful swimmer" in Greek, and the species name, *sapidus*, means "savory" in Latin. Around the Bay, they are known at restaurants and dinner tables for their succulent crabmeat; but in the water, they are defined by remarkable swimming skills and migrating patterns. A crab may spend part of the year in the Bay's northernmost flats of the Susquehanna River near Pennsylvania, and in the same season travel up to 200 miles south to saltier Virginia waters near the ocean to spawn.

A blue crab walks, tiptoes, and sprints sideways along the bottom on three pairs of pointed legs. A fourth pair, which are front legs, are modified into large claws on either side of the mouth. A fifth pair on the posterior side are swimming legs that widen into oar-shaped flippers. They can rotate at 20 to 40 revolutions per minute, allowing crabs to hover like helicopters over prey, or zip away to escape predators.

When spawning, a female releases one to eight million zoea, each 1/100 of an inch wide—the size of a single onion skin cell—at hatching. But they don't stay in the Bay. The larvae drift as tiny orphans into the open ocean, floating among plankton during the next four to seven weeks. They feed on microscopic plants and animals, and may even nip the skin of seashore waders. As larvae, they will molt as many as seven times, growing just a bit in between each molt.

Under a microscope, zoea look like tiny shrimp with huge eyes until they molt into a more crayfish-shaped megalop stage. Then, their carapace is only 1.5 mm across—one-sixth the size of a dog flea. They retain a shrimp-like tail for a while, but are already armed with claws. After one final molt to a true crab shape, they settle into the lower Bay grass beds.

Scientists once thought that blue crab larvae in the ocean ride a wedge of heavy salinity, hugging the bottom, back into the Bay. It's a habit of many estuarine fish larvae. But instead, "What appears to happen," says Hines, "is that they undergo a selective tidal stream transport on flood tides. The post-larval megalop stage swim vertically up to transport into the Bay on flood tides. Then, they drop down to the bottom on ebb tides to wait for another flood tide." Hines says the babies then sort of "walk their way into the grass beds." After several weeks of feeding to build up their swimming strength, they grow to a width of 3/4 inch, and begin migrating up the long Chesapeake estuary. The salinity of the water in the ocean is 30 parts salt per thousand (ppt), but by the time they reach the headwaters of the Bay and its major rivers, it is only about three ppt.

Most of the larvae are eaten by predatory fish such as croakers, bass, red drum, striped bass, or eels; by swamp dwelling birds such as herons and egrets; or by adult blue crabs. Many of the lucky few that survive to maturity are scooped out of the water in crab pots and, if they measure at least five inches wide, could wind up a person's dinner.

Case in point: Princess. She was a one-in-a-million crab simply because she reached adulthood. That's how many blue crab larvae survive hatching, washing out to sea, returning with tides to estuarine grass beds, and then migrating up the Bay. Rare survivors like Princess are not just lucky. They are smart.

As baby Princess began her trek north, she fed on tiny animals such as rotifers, worm larvae, and copepods. As she grew, she fed more on small

snails and soft-shell clams. But she stopped eating each time she had to molt and focused instead on hiding out in the "woods." Scientists discovered that woody debris is a very important molting habitat for juveniles—just one of the pieces to fit into the crab ecology puzzle. For example, the tapering depths of the 16-mile, wooded shoreline of the Smithsonian property on the Rhode River keep juvenile crabs safe from predation by adult crabs and fish. In contrast, juveniles are easy pickings along bulkheads and rip-rap rocks of private, developed shorelines.

While still a small juvenile, Princess sought cover in woody debris to molt every three to five days. When she reached two inches wide, she shed her rigid exoskeleton every ten to 15 days to accommodate the growth of her internal tissues. At the beginning of each molt, Princess formed a new, soft shell under her hard shell. When the new shell was fully formed, Princess absorbed water, swelled, and cracked open her old shell across the back, fracturing the claw shells, too.

Backing out of her old shell was slow and arduous, but in this process blue crabs deploy a bit of clever biology. Their tissues salvage inorganic salts from the old shell and deposit them into the new shell to thicken and harden it.



Throughout the summer, Princess continued to swim north, stopping in the shallows periodically to molt. By September, her carapace had grown to more than four inches wide, and she molted only once a month. She was ready for her final molt, just north of Annapolis. But this time, she wanted to be noticed. A female's final molt is her pubertal, or mating, molt.

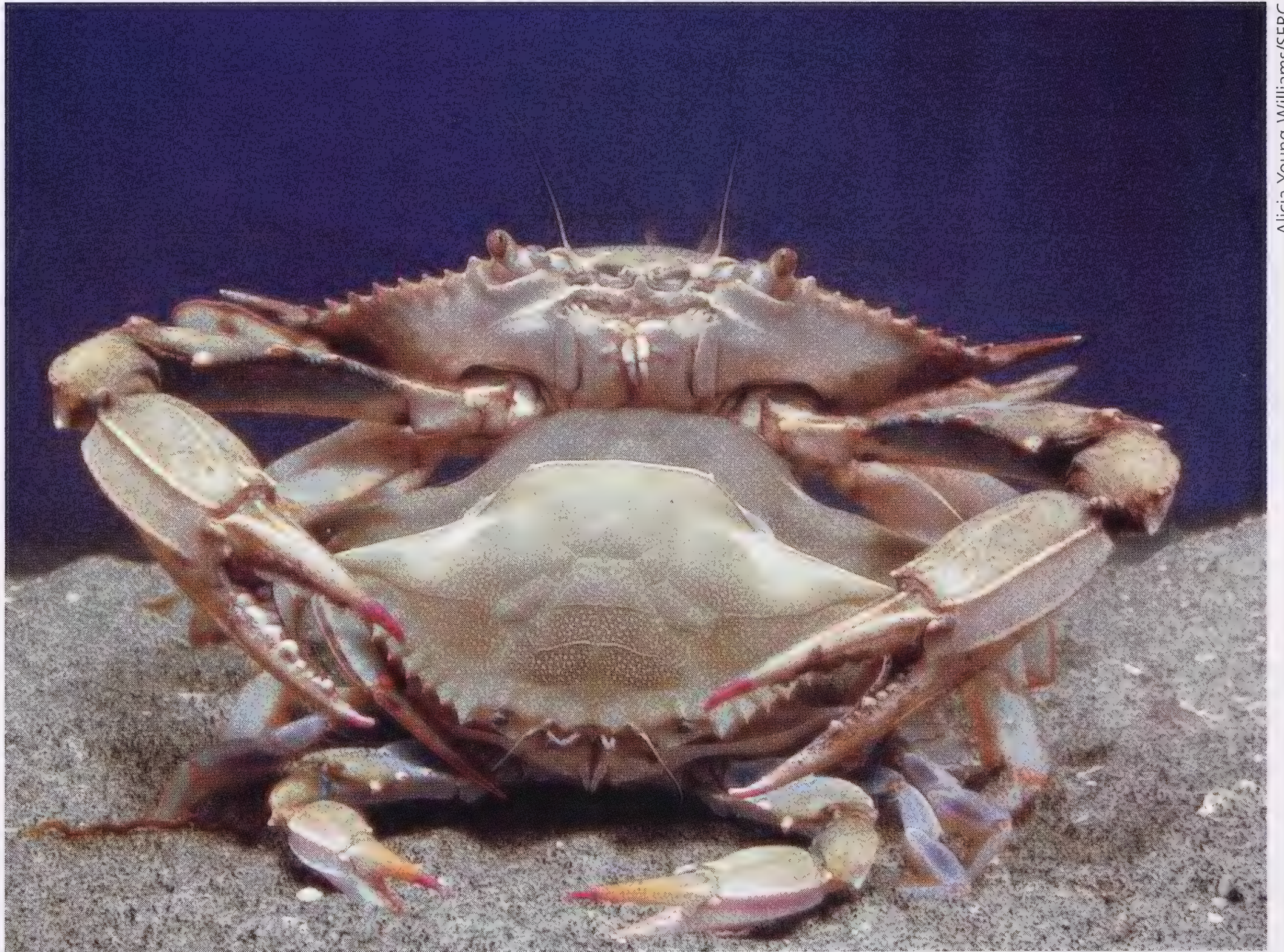
Cruising down from deeper water in the north was a large male—watermen call crabs like him jimmies. He was drawn to Princess' sexual pheromone, which acts like a mating perfume, and perhaps he noticed that the tips of her claws had turned a bright orange red when she matured, almost as though she had a manicure.

When Jimmie found Princess, she was not properly dressed, though; she was still in a hard shell. Blue crabs can't have sex unless the female is in a soft-shell state and his shell is hard. However, their nuptials began anyway, with a strange sexual ritual.

Usually, when blue crabs meet, nasty behavior ensues: mortal combat over prey, cannibalistic devouring of juveniles, or duels between big-clawed males over a receptive female. Sex is an absolute contrast, a gentle and attentive encounter. Jimmie hovered over his sook, as watermen say, his face just above hers. He then cradled her up to his body with his walking legs and held her close for two or three days to allow her to shed her hard shell. A male may continue to swim vigorously for miles in order to keep his mate out of harm's way. He may help her shed her hard shell.

When Princess molted and her shell was soft, the pair copulated for many hours. She received hundreds of sperm packets from Jimmie, perhaps a total of a billion male sex cells, and stored them in sac-like receptacles for later fertilizing. But Jimmie was not about to turn her loose. Although he would later cruise the Bay's mid latitudes for new mates, he continued to faithfully cradle and carry his partner for another two or three days until her new shell fully hardened.

Can we nominate Jimmie as the ideal husband? "No, that's the old dogma," says Lipcius. "What the male is mostly doing is protecting his sperm investment." Hines adds, "The impression you get is that



Alicia Young-Williams/SERC

A female's shell must be soft when she mates. If a male finds her when her shell is still hard, he may cradle her for several days to protect her from predators and help her molt. Once they have mated, he may continue to cradle her until her new shell hardens.

the adaptive advantage is for males to protect the soft female from predation and so that she can't be mated by another male." This is important because, if she mates with another male after Jimmie, the sperm of the two males could be mixed, and Jimmie's genetic legacy would be diluted.

So, Jimmie eventually split. Princess was single and pregnant. And instinctively, she headed home to Mom, or to where she left her mother, near the ocean. She followed the top edge of the Bay's deep main channel on the Eastern Shore side, longing for salty spawning waters to the south. When she got hungry one day, she crawled into a crabber's pot for a bite of fish bait, got yanked up suddenly, and was on her way to COMB.

Underwater Espionage

Today, blue crab scientists understand long-held secrets of the blue crab—intimate details of feeding, predation, mating, and migrating. To know so much, you'd think they've been living on the bottom with the crabs. In a way, they have.

Hines and zoologist Thomas G. Wolcott of North Carolina State University are pioneers in using ultrasonic telemetry to spy on crabs where they live, starting with adults more than a decade ago, and moving to juveniles in recent years. They designed waterproof trans-



A SERC scientist inserts a tiny wire into a juvenile crab's leg (above) before releasing it into the wild. If it survives the next few weeks, it will mature (below); and if it is recaptured by scientists, the wire will identify it as a hatchery crab.



mitters weighing only a few grams that they attach to crabs' backs. A tagged crab transmits a signal that scientists pick up with an underwater hydrophone and a receiver. "So we began to 'see' what their daily movements are and where they are feeding," says Hines.

They first experimented with a feeding tag, a set of electrodes attached to the crabs' mandibles. When a crab's mouth muscles contract, an electronic signal is transmitted. Hines explains, "We could then tell where the crab was by a location signal—a steady beep—and then superimposed on that was a signal for the contraction of that muscle. So we could tell where and when it was feeding."

Crab chewing patterns emerged. A crab eating a clam, for example, will twist it around to chip away pieces of its shell. The eavesdropping scientists captured the chewing pattern for clams: intermittent, with lots of pauses. If a crab eats a worm, the chewing pattern is steady slurping. Or, if it eats a small fish—soft parts on the outside and hard parts inside—the chewing pattern contains more pauses.

Another tag tracked the crabs' molting behavior. "We wanted to know where they went to molt exactly," says Hines. "They wouldn't go into the marsh, but were molting in the very shallow water at the edge of the marsh."

The scientists also learned to deploy "multi-channel tags," Hines says, to monitor two or more behaviors at once, such as feeding and fighting. They placed tiny reed switches and magnets on the upper claws. When a crab gets into an antagonistic fighting display, it spreads its claws in "a classic spread posture," he says, bringing the magnet close to the switch and changing its signal.

By combining data from feeding, molting, and fighting tags, the scientists mapped crabs' daily movements. "What we found was that the crabs typically meander around a couple hundred meters, probably walking, for many hours to a few days," Hines explains. "Then they suddenly move in a very oriented fashion at high speed, say 400 meters per hour, probably swimming part of that time. And then they will settle and meander again. This repeats over and over again." The team concluded that blue crabs linger near higher densities of prey, particularly clams. But why do they leave quickly when there are plenty of clams left?

"Well, this is where we brought in the fighting tag," says Hines. "First a crab would begin to tear open its prey, which then exudes a

chemical plume in the water that attracts other crabs. As more crabs built up at feeding sites, they fight. At some point, the crab just gave up feeding and fled to avoid the antagonistic interactions, to find a new prey patch." Studies with electronics, backed by laboratory experiments, solidified blue crabs' position as a keystone species in the Chesapeake. "[We] started looking at blue crabs in the system as top predators on benthic prey and how they regulate the abundance of clams, worms, and small crustaceans in these soft sediments

of the Rhode River and the Bay," says Hines. But are there enough clams, snails, and other crab food in the Bay's shallows to maintain greater numbers of crab releases?



COMB Hatchery Manager Oded Zmora (left) and COMB Director Yonathon Zohar (right) hold juvenile blue crabs.

Counting on a Recovery

One warm, sunny day in July 2004, COMB researchers drove to SERC and VIMS with 11,500 baby crabs for release. At SERC's boat dock, SERC research technician Midge Kramer directed students to sort and count crab juveniles in shallow water tanks. Little gray crabs scampered into and out of black plastic meshing in the tanks, the laboratory equivalent of wooded shorelines. Earlier, volunteers had stamped a tiny metal tag to each juvenile.

From a flat-bottom boat in the afternoon, SERC researchers poured thousands of the tagged juveniles into a cove at Boat House Creek on the Rhode River. Every week until the

fall, workers at SERC and VIMS dragged seine nets and small dredge sleds to sample the crab populations and check on their tagged crabs. The researchers waved an electronic wand over each slug of mud, grasses, and small benthic creatures they unearthed, and it beeped when it came near the metal tag of a COMB crab. It even found a tag in the belly of a croaker.

The data gathered indicate just how few crabs are left in the Bay. Kramer says, "When I first came here to SERC, we would get 50 to 75 juvenile crabs in one seine. Now, we get one juvenile after five seines." But she does find it encouraging that the scientists at both rivers are recording increases in crab numbers of ten to 200 percent. Some spring-released COMB crab juveniles are five inches wide by fall, and are ready to breed. The preliminary conclusion is that released crabs are surviving predation. But again, are they getting enough to eat?

On July 30, 2004, VIMS ecologist Rochelle Seitz and two students drifted their small research boat into calm gray waters in York River



Scientists pull a net through the water near shore hoping to capture hatchery crabs that were released weeks earlier. They measure and record the crabs they find, and in this way, they track the hatchery crabs' success in the wild.

coves to count snails. In full wet suits, the students knelt beside PVC-pipe squares they had positioned on the shallow shores using GIS mapping, and counted the number of snails inside. The concern is that because the blue crab has declined, there could be an abundance of snails. Too many snails have been shown to destroy salt marshes in Georgia and Louisiana by spreading a grass-killing fungus disease.

Nearby, another VIMS team swings a small crane over the water and dips a heavy dredge sled of chains to scrape the bottom. With each muddy lift of the sled, they sift for releases from COMB and wild crabs in Timberline Creek. They also count another favorite crab food, small clams *Macoma balthica* and *Mya arenaria*.

Seitz explains, "We are studying the food variability and getting closer to the issue of carrying capacity. For example, if you release thousands of crabs, they might wipe out the clams," and cause an ecological imbalance, she says. "But on the other hand, if they balance out, and the clams survive the addition of more crabs, then you can carry more crabs." Gut contents of crabs at the York River revealed about 50 percent clam material, she says. "So, this research is measuring bottom-up controls for crab ecology." It's also showing that coves may be just as effective nurseries as grass beds. "We estimate that we have as many crabs in the upper river coves as we have in the grass beds," she adds.

With very little precedent, Zohar and his COMB team had spectacular success in developing a blue crab hatchery program, according to leading fishery experts meeting in Baltimore last year. And beyond 2005, finding and identifying the released crabs may be easier. COMB researchers will soon identify a genetic marker, from their completed mitochondria genome map of the blue crab, that will

distinguish crabs from the bloodlines of Princess and other mothers of the hatchery project.

And, because ecological studies suggest that there is a higher carrying capacity in the Bay for blue crabs, Zohar is ramping up, establishing grow-out nurseries at two coves in the Bay's middle latitudes. According to waterman Mick Blackistone, who is coordinating the nurseries, "We should be releasing at least a half million crabs by next year." COMB will continue to rear larvae up to the megalop stage, 300,000 in each massive tank. But, "when they start putting on their clothes [shells], we will ship them to outside nurseries for scaled-up releases," explains Zohar.

Sitting on the boat dock at SERC, post-doctoral researcher Eric Johnson, a recent addition from North Carolina State University, is also optimistic. "If you can use this opportunity to augment, you have a chance," he says. His N.C. State colleagues are collaborating with Blue Crab Enhancement Project scientists on ecology studies in another traditional blue crab habitat, the Pamlico Sound near the Outer Banks, where crabs have also declined by 80 percent in recent years. "As we are releasing the juveniles into the wild, at some point we will see if they become mature... But there is tremendous mortality out there that hopefully we can bypass. So the question is: Are the hatchery crabs to be fish food—or are they surviving?" Z



—Stephen Berberich lives in Waldorf, Maryland. He has written about wildlife conservation, science, and the environment, and contributed to a story on the National Zoo's molecular lab that was published in the D.C. area's Journal newspapers.

The Secret Life of Lobsters: How Fishermen and Scientists Are Unraveling the Mysteries of Our Favorite Crustacean

Trevor Corson. 2004. HarperCollins Publishers, New York. 289 pp., hardbound. \$24.95.

All the ingenious men, and all the scientific men, and all the imaginative men in the world could never invent, if all their wits were boiled into one, anything so curious and so ridiculous as the lobster. —Charles Kingsley (1819-1875)

Kingsley didn't know the half of it. As revealed in *The Secret Life of Lobsters*, these arthropods have evolved amazing adaptations for survival and reproduction, most of which were discovered in the past 25 years or so. Moreover, if you agree with the sentiment of an anonymous writer that "a truly destitute man is not one without riches, but the poor wretch who has never partaken of lobster," *The Secret Life* will both whet your appetite and give you food for thought, not to mention a store of trivia to add sparkle to your dinner-table small talk, such as:

- Early European settlers of New England looked upon lobsters "as a kind of junk food that was fit only for swine, servants, and prisoners."
- Male lobsters engage in, literally, pissing contests to settle disputes over dominance. A losing male remembers his defeat at the claws of another and capitulates without a fight on their next meeting—but only if he can smell the other's urine.
- Female lobsters cement their fertilized eggs to the undersides of their tails and carry them for about ten months until they hatch; older, larger females tote around as many as 97,000 eggs at a time. Once hatched, the babies are on their own.
- Lobster traps are remarkably poor at catching lobsters. In one 12-hour period, lobsters approached a scientist's "lobster-trap video," 3,058 times. But only 45 lobsters entered the trap, 40 of which walked back

out again. Of the five hauled up in the trap, three were under the legal size and had to be thrown back.

Author Trevor Corson is no armchair lobster aficionado. He grew up on a tiny Maine island, where most residents make a living as lobstermen. For two years he held one of the yuckiest jobs going, sternman on a lobster boat. Among his tasks was filling mesh bags with rotting fish parts to bait lobster traps, during which "rancid brown juice sloshed over the hems of his gloves and down between his fingers. . . [and] droplets of bait juice splattered over his face." On other boats, he accompanied scientists as they went about such arcane rituals as vacuuming the ocean floor to count baby lobsters and tethering lobsters like dogs on leashes to find out which other creatures eat lobsters. He partook of scientific meetings with lobster biologists and beer parties with lobstermen.

But Corson never puts himself center stage. Instead, lobstermen (and a few women), lobster biologists, and lobsters themselves are the protagonists of a set of interlocking stories spanning more than 25 years that reads more like a novel than a work of nonfiction. His colorful writing and sometimes salty language make *The Secret Life* a pleasure to read; not every writer can make scientific findings both funny and dead-on accurate.

The book revolves around a single question: Is the Maine lobster fishery sustainable? Corson has crafted a surprisingly suspenseful plot around the search for an answer. And it's not merely an academic question. The livelihoods of lobstermen, the reputations of biologists, the survival of the American lobster, and the gustatory pleasure of millions of lob-

ster eaters depend on getting it right.

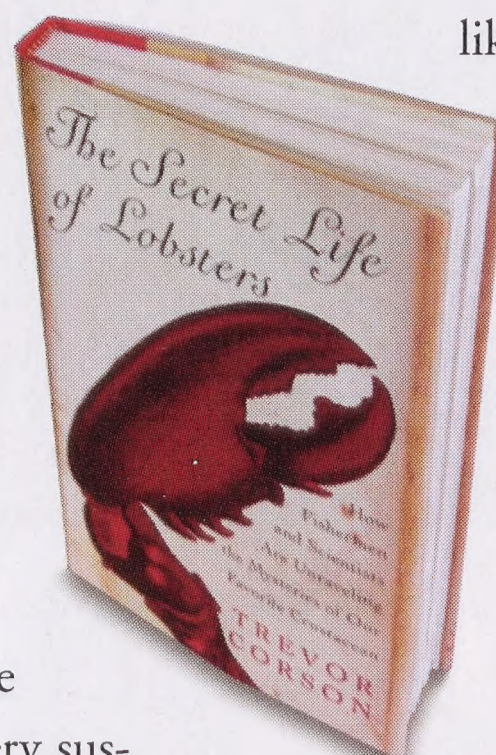
The concern of state and federal resource managers about overfishing lobsters was fueled by the collapse of the Atlantic cod fishery. They feared a repeat of this tragedy, despite the lack of evidence that lobsters were being overfished. In fact, there have been consistently high lobster harvests in the past quarter century. Managers wanted to increase the size at which a lobster could be legally harvested—anathema to the lobstermen for its negative impact on their potential income—arguing that this would allow more females to reproduce before being caught. On the other side, the lobstermen argued that their own conservation measures, which included never harvesting a female carrying eggs, were sufficient to ensure the health of the lobster population. Entering the fray was an assortment of scientists studying lobster ecology to resolve the issues. Ironically, among the things they learned is that lobsters' current nearshore abundance is likely the result of the cod's disastrous decline—it turns out that cod

like to eat lobsters even more than people do.

All evidence thus far suggests that the lobster fishery is sustainable—and that the lobstermen's conservation strategy works. The story ends with lobstermen enjoying their prosperity, at least for now. But if cod recover, as conservationists hope, will that trigger a lobster crisis?

Corson offers this note of caution: "For all the mysteries that lobster scientists had unraveled, more secrets waited to be discovered." In nature, the only constant is change.

—Susan Lumpkin

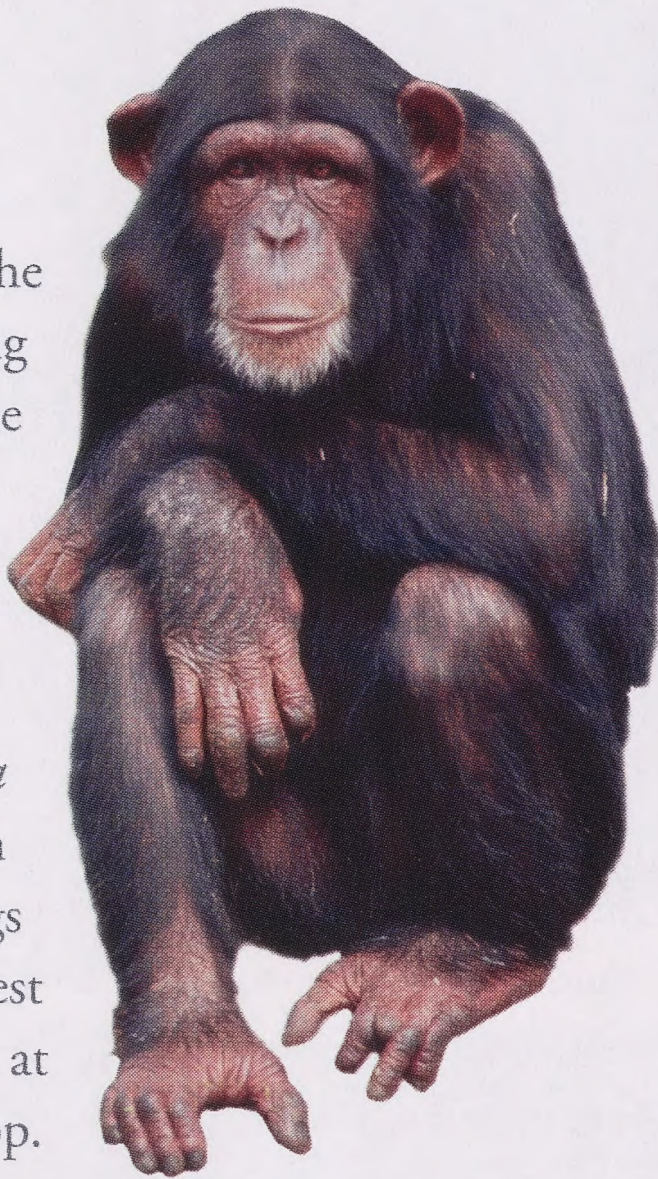


BioAlmanac

by Emily Huhn

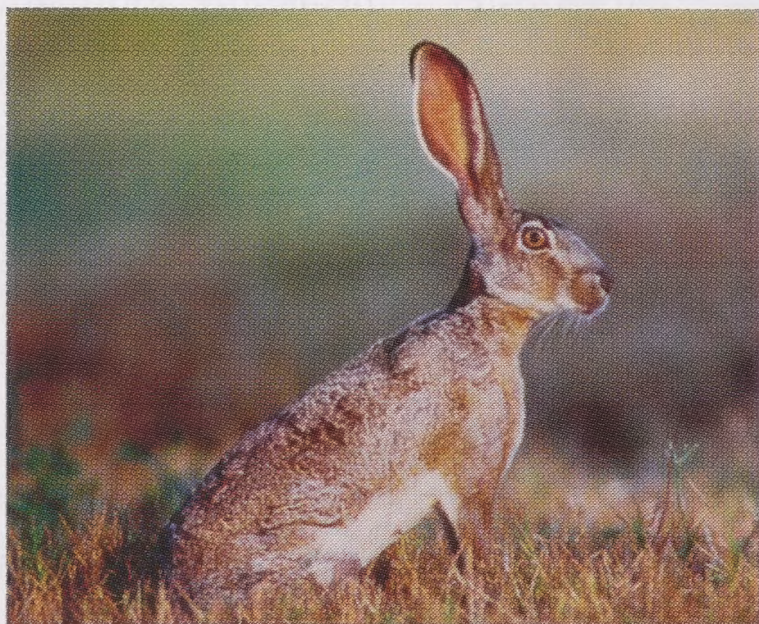
A Chimp's Toolbox

Chimpanzees in the Goulougo Triangle region of the Republic of Congo are discerning tool users, according to a new study. When fishing for a tasty termite meal, the chimps (*Pan troglodytes troglodytes*) don't rely on just one tool—they use several sets of specialized sticks and twigs. Different tool sets are used at underground nests than at aboveground nests. To penetrate underground nests, the chimps push stout sticks from *Thomandersia hensii* trees into the ground, puncturing access holes in nest galleries. At aboveground nests, the chimps use twigs from a variety of nearby species of trees to perforate nest walls. For probing the holes and fishing out termites at either nest type, they use thin stalks of *Sarcophrynium* spp. plants, which they sometimes draw through their teeth to fray the ends into a brush tip. The chimps often arrive at nests with these tools already modified for the task at hand. The study, published in the November 2004 issue *The American Naturalist*, is the first to use a remote video monitoring system with infrared motion sensors to record chimp tool use. The authors will expand the study to monitor tool use in other chimpanzee communities in the Goulougo Triangle.



What's in a Name?

European settlers of the American Southwest likened the long ears of black-tailed jackrabbits (*Lepus californicus*) to donkeys' ears, and so named the animals "jackass rabbits." Mark Twain endorsed this moniker in his book *Roughing It*: "...We saw the first specimen of an animal known familiarly...as the 'jack-ass rabbit.' He is well named. He is just like any other rabbit, except that he is from one-third to twice as large, has longer legs in proportion to his size, and has the most preposterous ears that ever were mounted on any creature but a jackass." The common name was eventually shortened to "jackrabbit."



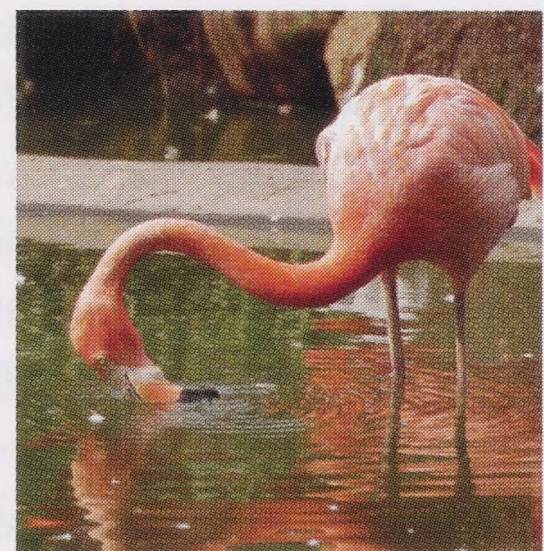
Black-tailed jackrabbits are really hares, meaning they are larger and leaner than rabbits, have longer legs, and have black tips on their ears. Whereas baby rabbits are born blind, naked, and helpless, baby hares are born wide-eyed, furry, and ready to hop. Only members of the genus *Lepus* are correctly called hares, while the rest of the Leporidae family are rabbits. In common parlance, "hare" and "rabbit" are often used interchangeably and sometimes incorrectly. *Caprolagus hispidus*, for example, is called both "bristly rabbit" and "hispid hare," even though it is a rabbit and not a hare.

Short-tailed shrews (*Blarina* spp.) are the only poisonous mammals in North America. They immobilize insects and other prey with their toxic saliva, thus keeping their meals alive and fresh for consumption for up to five days.

Where Are Male Angler Fish?

About two miles below the ocean's surface swim fish with gaping mouths, fearsome teeth, and bioluminescent lures dangling from their heads. Looks aside, angler fish (*Melanocetus johnsoni*), also known as common black-devils, are bizarre creatures with a strange sexual dimorphism. For a long time, scientists found only female anglers—until they noticed tiny lumps attached to the females' bodies. Turns out the lumps are the males, which parasitize their female mates. A male bites into a female's skin and his mouth fuses to her body. His bloodstream combines with hers, and his digestive tract degenerates until he becomes totally dependent on her for nourishment. He even loses his eyes and most of his internal organs, but not his testes, which provide sperm to fertilize the females' eggs. Scientists have found individual females toting several males through the deep.

Fact or Fiction: Flamingos Eat Upside Down

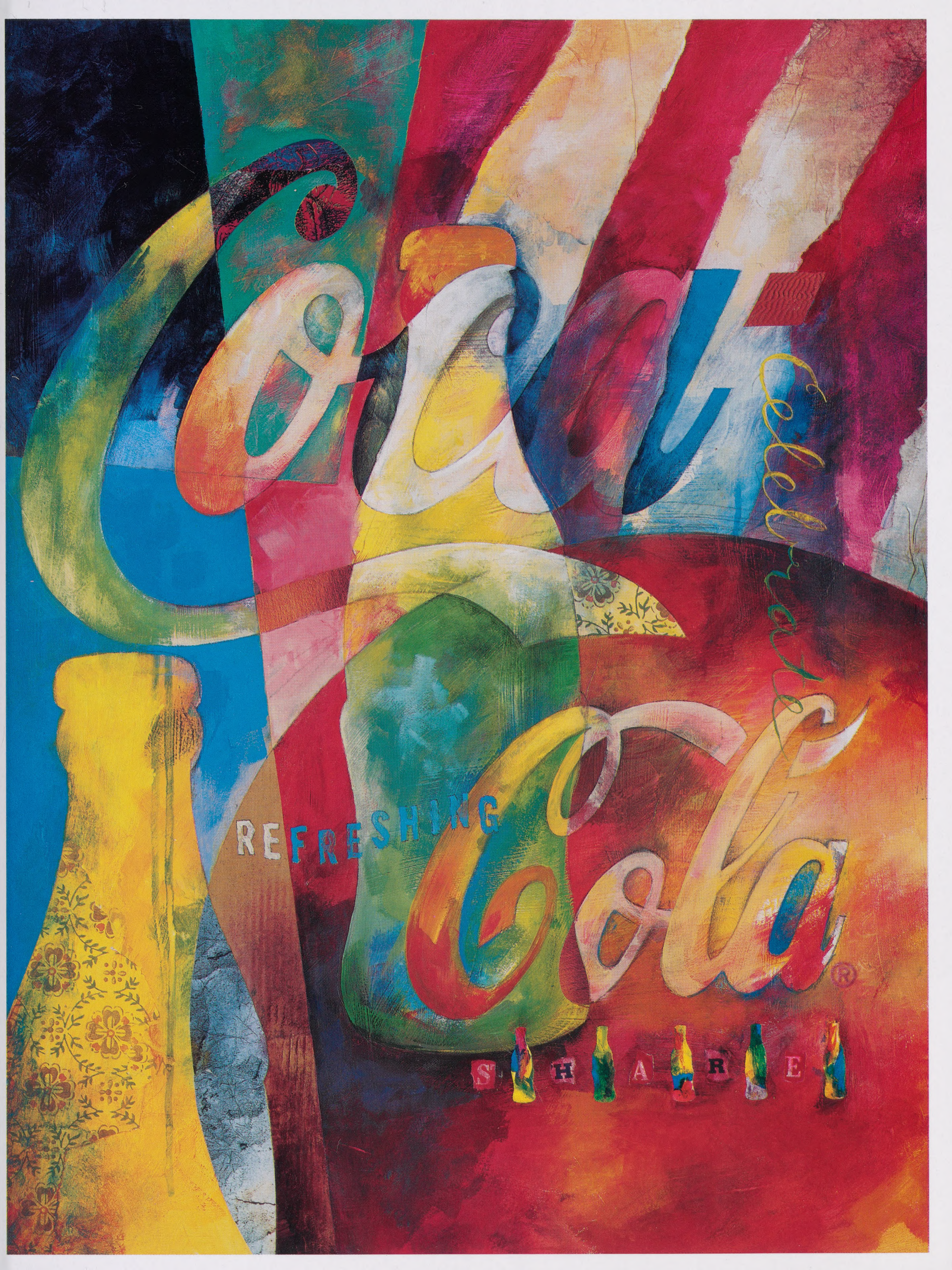


Flamingos filter their food much like whales, and they do feed with their heads upside down. They submerge their open bills, retract their tongues to

suck in tiny invertebrates, mollusks, crustaceans, and water, then close their bills. Pushing their tongues forward, they trap food in comb-like structures called lamellae that line their bills, and send the water out of the sides of their mouths. As flamingos draw their tongues back again, backward-facing spines on their tongues help slide the trapped food down their esophagi. Each cycle takes about four seconds.

In Season

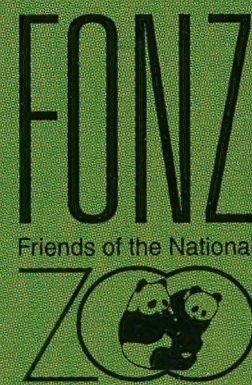
In eastern forests, a shrubby plant called witch hazel (*Hamamelis* spp.) blooms from autumn's first frosts through winter's late snow flurries. Each flower has four small, fragrant, yellow to copper-red petals that unfurl on sunny days and curl up when night falls or temperatures dip below freezing. After the flowers fade, seed capsules develop and ripen the following year. They explode when mature, shooting out two oily black seeds up to 30 feet away. Chipmunks, squirrels, rabbits, white-tailed deer, and ruffed grouse feed on the expelled seeds.



Help the otters get to their new home.



Make a donation to the Asian small-clawed otters at the Smithsonian's National Zoo. The new otter habitat on Asia Trail will feature a spacious wetland environment to encourage natural breeding and support the survival of this charismatic species. The exhibit will also facilitate reproductive research that can be shared with scientists globally to help reduce threats to otter populations. The total project will cost more than \$2 million. Your tax-deductible contribution will help make this plan a reality. **Find out more about how you can help at www.fonz.org/otters.htm**



Friends of the National Zoo, 3001 Connecticut Avenue, NW, Washington, D.C. 20008, www.fonz.org